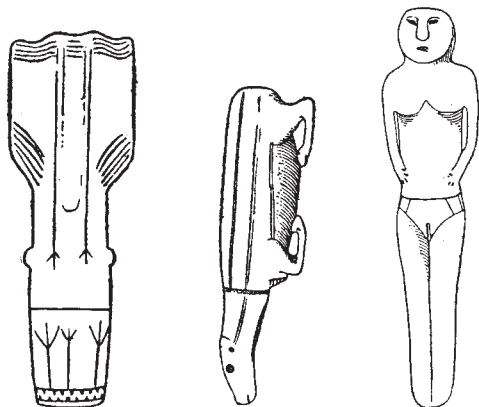


This form of ornamentation is believed to be peculiar to Eskimo work, and does not occur in those parts of America or Asia which are beyond the sphere of Eskimo influence. The controversy, as now stated, turns mainly upon the diminutive knobs found in the Eskimo needle-case group, which appear to serve no practical end, and are, it is believed, purely conventional. This type of conventional ornament, according to the view of Dr. Boaz, is found to develop gradually into an animal design, such as that of a crouching beast, the knobs in the assumed later forms becoming heads, such as those of a seal, or even a partially or fully draped human figure, curiously reminiscent of the growth of the aniconic Greek pillar into an anthropomorphic image.

Dr. Boaz argues that it is impossible to believe that in this group the animal form was primitive; in other words, he attempts to prove that the seal-headed and similar more advanced designs could not have been developed by a degradation of a type which was originally more highly specialised. The process, it is contended, was the reverse of this, and the crude knob preceded the animalistic and later developments. "If we were to apply," he urges, "to the present series the theory of the origin of the conventional form from realistic motives, it would be exceedingly difficult to account for the general uniformity of fundamental type. It seems to me that on the basis of this theory we could not account for the diversity of realistic forms and the uniformity of the general type."



Characteristic forms of needle-cases, to show the evolution of type.

Neither does it seem possible to account for the series of types by the assumption of any influence of technic; and my impression is that the only satisfactory explanation lies in the assumption that the multifarious forms are due to the play of imagination with a fixed old conventional form, the origin of which remains entirely obscure. This I freely acknowledge. If, however, we are to form an acceptable theory of the origin of decorative designs, it seems a safer method to form our judgment based on examples the history of which can be traced with a fair degree of certainty, rather than on speculations in regard to the origin of remote forms for the development of which no data are available." Hence he explains decorative forms as "the results of the play of imagination under the restricting influence of a fixed conventional style." This influence of imagination is illustrated in the case of necklaces and leggings made by the American Indians, in which the tendency to use rhythmic repetitions of varying forms is specially apparent. Dr. Boaz sums up the discussion by remarking that "the development of decorative designs cannot be simply interpreted by the assumption of a general tendency towards conventionalism, or by the theory of an evolution of technical motives into realistic motives by a process of reading in; but that a considerable number of other psychic processes must be taken into consideration if we desire to obtain a clear insight into the history of art."

It is impossible to discuss in detail the views of Dr. Boaz in this important contribution. The weak points in

the argument seem to be:—first, that the ultimate origin of the flanges and knobs in this group of objects remains unexplained; secondly, that it seems rash to assume that the historical development of the Eskimo form of design can be definitely established; thirdly, it may be urged that the objects themselves are of too special a type and found in a too limited area to supply a safe basis for such a wide induction as that which is here applied to the evolution of primitive art in general. It seems clearly necessary that a fuller comparison of this group with the types produced by other neighbouring tribes should be a preliminary to any further discussion of their origin and meaning.

It seems not impossible that this Eskimo form of decoration may be due to special influences of environment, technique, and general culture with which we are as yet imperfectly acquainted. This paper, however, with its abundant illustrations and ingenious interpretations of the evolution of decorative forms, must be taken into account by all future writers on the subject. In any case, it illustrates the danger, in the present imperfect state of our knowledge on this and other subjects connected with the thought and culture of so-called "primitive" man, of the dogmatic assumption that any one theory will account for the workings of the artistic faculty when exposed to the varying influences of imagination, culture, and environment.

THE BRITISH ASSOCIATION.

SECTION D.

ZOOLOGY.

OPENING ADDRESS BY SIDNEY F. HARMER, Sc.D., F.R.S.,
PRESIDENT OF THE SECTION.

THE British Association meets this year for the fourth time in Dublin. The last occasion was just thirty years ago, when Sir William Flower presided over Section D, while Prof. Huxley was Chairman of the Department of Anthropology, at that time not raised to the dignity of a separate Section, and Sir Wyville Thomson was President of Section E. The last Dublin meeting was fortunate in having among its officers men who have left an enduring mark on Zoological science.

I can hardly come to the more immediate subject of my Address without referring to the death, on March 9 last, of Henry Clifton Sorby, who had been a member of the Association for nearly fifty years. Dr. Sorby was President of Section C in 1880; but although he does not appear to have presided over Section D, many of his sympathies were with Zoology. He belonged to a type which is becoming almost extinct with the increasing specialisation of science, having done pioneer work in more than one branch. His interest in Chemistry was no doubt responsible for his having taken up the subject of the pigmentation of animals, by his researches on which he is probably best known to Zoologists. During recent years he had devoted particular attention to the study of the marine fauna of East Anglia.

According to the popular estimate, Zoology is regarded as the branch of science that has perhaps the least reference to the details of practical life. The importance of the applications of Chemistry, Physics, Geology, Botany, and Physiology to questions which involve the welfare of the human race is obvious and universally admitted. But pure Zoology is often supposed to be a study of merely academic interest, and its relation to the practical concerns of mankind is not always apparent. It is no doubt true that many of the investigations undertaken by Zoologists are of a highly special nature; and yet when the sum total of the results achieved by workers in this science is estimated it will be found that the contributions of Zoology to the common stock of human knowledge are by no means of restricted application.

There is no conception which has more profoundly influenced thought in all branches of knowledge than the idea of organic evolution, in the development of which Zoology has shared the honours with its sister-subject, Botany. The present summer has seen a memorable event in the celebration by the Linnean Society, on July 1, of the fiftieth anniversary of the communication to that

society of Papers, by Darwin and Wallace, which revolutionised the whole of Biology. There can surely have been few occasions when the commemoration of the jubilee of an epoch-making discovery has been attended by the man whose work was thus recognised. I am sure that I am expressing a unanimous feeling in saying that the award of the first Darwin-Wallace medal on that occasion to Mr. Wallace in person was a source of deep gratification to all men of science, and that the presence at the same meeting of others whom all Biologists must regard with peculiar respect gave the occasion a perfectly unique character.

The present century has seen a remarkable development of the study of the problems of heredity and variation, largely as the result of the interest awakened in the resuscitation of Mendel's experimental work from the oblivion in which it had remained for so many years, though the general problem is being attacked concurrently by investigators who attach more importance to the statistical method of study. Prof. Bateson, who has given the name "Genetics" to the experimental study of heredity, chose the advances made in that branch of Biology up to 1904 as the subject of his able address to Section D in that year. Some of the more recent conclusions of the workers in Genetics are to be discussed by this Section during the present meeting. It cannot be doubted that an accurate knowledge of the principles of heredity is destined to exert a marked influence on the practical concerns of humanity.

The study of diseases which are due to parasitic Protozoa has made striking progress during the last few years. Protozoology has become a distinct branch of Zoology, represented by its own journals and its own professors and lecturers, while it can command the resources of the schools of tropical medicine where researches are being carried on from which great benefits to humanity may be anticipated. Malaria, sleeping sickness, yellow fever, and the numerous diseases of domestic animals due to parasitic Protozoa such as Trypanosoma, Spirochaeta, and Piroplasma, are some of the complaints which are now recognised as the objects of Zoological study. Most of these diseases are transmitted by blood-sucking Insects and Arachnids, an accurate knowledge of which has become a matter of pressing practical importance.

The history of Protozoology affords a complete vindication of the importance, even from a utilitarian standpoint, of conducting scientific investigations for their own sake, even though the likelihood that they will ever have any practical bearing may not at first be apparent. Some years ago it would have been generally supposed that the study of Ticks was a case of this kind, and that it could at most be of interest to the special students of the Arachnida. How far such a view would have been from the truth is well known, but we are suffering now from the comparative neglect of this group of animals in the past. There is still no satisfactory monograph by the aid of which the species of Ticks can be discriminated, and there are few Zoologists who would be prepared to express an opinion with regard to the determination of even those species that are the commonest and the most injurious. While it is clear that the investigation of the Arthropod carriers of parasitic Protozoa is essentially a Zoological question, it is equally true that the elucidation of the parasites themselves is largely dependent on the results that have been achieved by Zoological investigators who have worked without any thought of a practical outcome. The late Prof. Schaudinn, to whom we owe so many brilliant results in the study of the Protozoa, commenced his investigations from the Zoological side, and continued them in their applications to preventive medicine. It is generally admitted that the study of many of the tropical diseases can only be carried on by means of a due co-ordination between Zoological and Medical methods of inquiry.

As a further instance of the manner in which Biological science may react on other studies, I may mention the interesting theory which has recently been developed by Mr. W. H. S. Jones,¹ to the effect that the decay of the

ancient civilisations of Greece and Rome was largely due to the introduction of malaria into those countries.

I can do no more than allude to Economic Entomology, a subject which has at present received but little official support in our own country, although its importance is fully recognised abroad, particularly in the United States of America, where large organisations are devoted to the combat with the Insect enemies of agriculture. We are fortunately spared some of the worst of the foes of vegetation which devastate other lands. But many of our cultivated plants suffer severely from the ravages of Insects and Arachnids; and it is perhaps not too much to hope that more systematic measures will some day be taken in this country to disseminate the knowledge by which this injury to agriculture may be minimised.

As a last illustration of the way in which Zoology comes into relation with practical matters, I may allude to the question of fishery investigation. Although much remains to be done in this connection, the importance of purely scientific work has been to some extent officially recognised. The Board of Agriculture and Fisheries in England, the Scottish Fishery Board, the Fisheries Branch of the Department of Agriculture and Technical Instruction for Ireland, and other organisations which are mainly or entirely supported by private funds, are in part devoted to the interests of the fishing industry. The Government has latterly participated in an international investigation of the North Sea, as the result of which many interesting facts have been recorded with regard to the life-histories of food-fishes, their migrations at various periods of life, the age at which they become sexually mature, and the nature of their food. These are questions that demand study by experienced Zoologists; and the interrelations of food-fishes and the organisms on which they subsist or with which they come into competition are so complex that a full study of the entire marine fauna appears to be a necessary preliminary to the elucidation of the questions of immediate practical utility.

I have tried to indicate that Zoology is a subject that has important relations with the practical concerns of mankind. But in Zoology, as in other branches of science, the principal advances have been made by investigators who have studied it for its own sake, without thought of the practical outcome. It would undoubtedly be a misfortune should an entirely utilitarian spirit become dominant in the pursuit of science. In the full conviction of the truth of this statement I venture to invite your attention to certain questions connected with the Polyzoa—a somewhat neglected group of animals which I do not profess to be able to connect in any direct way with practical matters. In choosing this subject I have been influenced by the belief that it is well for the President of a Section to speak on matters of which he has had practical experience.

During the course of my studies on the Polyzoa I have been conscious of the existence of many unsolved problems and difficulties, some of which are connected with the functions, distribution, and variations of certain remarkable appendages known as "avicularia" and "vibracula." Although the facts bearing on the significance of these organs are familiar to specialists only, they appear to me capable of throwing light on questions of general Biological interest, particularly in connection with variation in animals that increase by budding.

The statement has often been made, as the result of a theoretical conception of the physical basis of heredity, that the asexual method of reproduction gives rise to little or no variability. Although there are many reasons for doubting the validity of this conclusion, it may be well to state at the outset that the Polyzoa, which are without exception characterised by increasing in an asexual manner, show a high degree of variability in the individuals thus produced. So much is this the case that the want of fixity of type which results from the tendency to vary renders the definition of species particularly difficult in this group of animals.

Meeting as we do at Dublin, there is a special appropriateness in discussing the Polyzoa, as a tribute to the memory of a distinguished Irish naturalist, J. V. Thompson, to whom we owe not only the name Polyzoa, but also the first clear conception of what these animals really are.

¹ "Malaria: A Neglected Factor in the History of Greece and Rome." (Cambridge: Bowes and Bowes, 1907.)

In the fifth memoir, published at Cork in 1830, of a short but brilliant series of Papers,¹ Thompson was the first to demonstrate the essential nature of the differences between the Polyzoa and the other "Zoophytes" with which they had previously been classified. G. J. Allman, who at a later period did so much to throw light on the structure and natural history of these animals, particularly by his classical monograph on the Fresh-water Polyzoa,² was also an Irishman, who was born at Cork, and for some years held the professorship of Botany in the University of Dublin. Thomas Hincks, another worker who was pre-eminent for his knowledge of the Polyzoa and for the importance of his researches in this field, held professional appointments both at Cork and at Dublin for several years.

The Polyzoa are a group which is quite unknown to most persons who are not Zoologists. Before coming to my special subject, the variations of the avicularia, I may for this reason, perhaps, be excused for attempting to explain what the Polyzoa are like, and, in particular, what are the nature and functions of the structures we have to discuss.

The Polyzoa are a Class of aquatic organisms of world-wide distribution, and including a large number of species. They occur both in fresh water and in the sea, and the marine forms are found from between tide-marks to the deepest abysses of the ocean. Some of the species are among the commonest objects of the sea-shore, and others may be obtained in numbers by the use of the dredge or trawl. They often occur as delicate encrustations, usually calcareous, on plants, stones, or shells; or they may assume the appearance of sea-weeds, corals, or Hydroids. Although most of them are of comparatively small size, they are usually large enough to be recognised by the naked eye, while the largest of them reach a diameter of a foot or two.

The Polyzoa are always colonial animals, the colony consisting of a number of individuals which are in organic connection with one another, though they may appear at first sight as a series of isolated units. Each of these units consists of a body-wall, which is usually calcified and is termed the "zoecium," since it was at one time supposed to constitute a sort of house for a zooid known as the "polypide." The idea of a dimorphism of individuals expressed by this nomenclature is no longer accepted, but the terms themselves are still conveniently employed for descriptive purposes. The polypide consists in reality of the visceral mass of the zoecium, together with the series of ciliated tentacles which are used for the capture of food. The tentacles are protrusible, but are commonly found retracted into the interior of the zoecium, in which condition they lie in a thin-walled introvert or "tentacle-sheath," which opens to the exterior by an "orifice" in the wall of the zoecium. In the suborder Cheilostomata, to which my remarks will principally refer, the orifice is closed, during the retracted condition of the polypide, by a chitinous lid or "operculum."

In the great majority of cases the colony is inaugurated by the fixation of a free-swimming larva, which has been produced from an egg by the ordinary sexual method. On the completion of its metamorphosis the larva becomes the first zoecium of the colony, and is then known as the "ancestrula," a term introduced by Jullien to signify that it is the ancestor of the future colony. In a large number of species belonging to the most diverse genera of Cheilostomes the ancestrula has a certain definite character which appears to have no relation to that of the individuals to which it gives rise by budding. The type of ancestrula in question has a striking resemblance to a single zoecium of many of the species of the existing genus *Membranipora*, and is characterised by having a series of marginal spines which surround a region closed by a chitinous membrane, at one end of which is situated the operculum. That this form of ancestrula has a definite significance is indicated by its wide occurrence among Cheilostomes and by the fact that the same cannot be said of any other form of ancestrula, and is confirmed by the palæontological occurrence of *Membranipora* as one of the earliest genera of Cheilostomata.

The ancestrula gives rise by budding to daughter-zoecia, which usually assume from the first the characters proper to their species. In the growing colony the formation of new zoecia takes place at the expense of a marginal zone, which contains the tissues concerned in the bud-development. Omitting the consideration of special regenerative processes which may take place, a zoecium which has once been constituted at the growing margin of the colony does not, as a rule, possess the power of giving rise to new zoecia, although it commonly has the faculty of producing sexual cells from which free larvæ may develop.

In the majority of the species of Cheilostomata many of the individuals of the colony have the form of the so-called avicularia. An avicularium is characterised by possessing a chitinous "mandible," which can be closed with great force by strong occlusor muscles, the organ being thus essentially of a prehensile nature. There can be little doubt that the mandible is a modification of the chitinous operculum which closes the orifice of the tentacle-sheath in Cheilostomata. It thus follows that avicularia are restricted to this particular division¹ of the Polyzoa. In the avicularium the operculum has become relatively and often absolutely enlarged, and its muscles have become more powerful than those of the unmodified zoecia. The internal viscera have, as a rule, disappeared, and there are thus neither tentacles nor alimentary canal. The body-wall, or zoecium, has become a case which contains the muscles, while part of it has been prolonged into a beak-like structure or "rostrum," which, with the chitinous mandible, constitutes the prehensile mechanism.

In *Bugula* and its allies the avicularium has the form to which its name refers, and has a striking resemblance to the head of a bird like an eagle or vulture. This resemblance is due, not only to the general form of the structure, but also to the hooked and beak-like shape of its rostrum and to the narrow neck by which it is connected with the zoecium on which it is borne. The avicularia of *Bugula* have considerable powers of movement, and in the living condition they may be seen to bend backwards and forwards on their flexible neck, their range of action being thus considerably enlarged. The mandible is ordinarily held wide open, but it closes with great force when some foreign object is placed between the jaws. An avicularium which has in this way seized a small worm, for instance, is known to be able to retain its capture for many hours, in some cases for more than an entire day.

In the majority of Cheilostomata the avicularia are, however, not stalked. They occur scattered over the colony in a considerable variety of positions, and usually appear as appendages rigidly connected with the walls of the zoecia.

More than one attempt has been made to explain the functions of the avicularia. The distribution of these organs indicates, I think, that the simplest and most obvious explanation is the correct one—namely, that, like the pedicellariæ of Echinoderms, they are defensive organs. The ordinary unmodified opercula probably have the same function in many cases; and if account be taken of the fact that the avicularium is morphologically a modified zoecium it becomes easy to understand that the defensive office of the opercula has been made more efficient in specially modified zoecia which concentrate their energies on this one function alone.

A casual inspection of a number of Cheilostomes taken almost at random reveals the fact that the avicularia are specially common in the immediate neighbourhood of the orifice of the tentacle-sheath and of that of the "compensation-sac."

This is a thin-walled cavity which in a considerable proportion of the Cheilostomes opens to the exterior at the proximal border of the operculum. Its principal function is to permit protrusion and retraction of the polypide to take place, since in a zoecium with completely rigid walls the act of protrusion could not occur if the temporary removal of structures of considerable size were not compensated for by the admission of water into the space included by the rigid body-wall. At each movement of

¹ It may be noted that Palæontologists have described structures which they have regarded as avicularia in Polyzoa which do not belong to the Cheilostomata.

¹ "Zoological Researches and Illustrations."

² Ray Society, 1856.

protrusion, therefore, a volume of water corresponding with that of the protruded organs is admitted into the compensation-sac, the dilatation of which, by means of radiating muscle-fibres, is the cause of the protrusion, and is again evacuated when the polypide is retracted. These alternate actions of filling and emptying the compensation-sac with water from the outside are probably of importance in the respiration of the animal. The advantages of having avicularia in such a position that they can guard the orifice from which the tentacles are protruded and that of the compensation-sac are too obvious to require detailed discussion.

The avicularia probably afford little if any protection against the attacks of the larger foes, such as Fishes, Echinids, and Nudibranch Molluscs, which are said to browse on Polyzoa. But there is one group of enemies against which the opercula and the mandibles are probably particularly effective. These are encrusting organisms, including other species of Polyzoa; and indeed the enemies against which a Polyzoon has to provide are probably in a special degree the members of its own class.

In many Polyzoa which afford large surfaces suitable for the growth of encrusting organisms the older parts of the colony, where the opercula and mandibles are no longer in working order, do actually harbour large numbers of encrusting Polyzoa, Sponges, Ascidians, and other organisms. These are usually absent in the active parts of the colony nearer the growing margins. In these positions the only animals which obtain a footing are such forms as the Infusorian Folliculina, adapted by its minuteness to find a place between the defensive appendages, or such organisms as are attached by means of delicate creeping stolons or rootlets that can find their way between the opercula and mandibles without being damaged by them. A branching species fixed by a narrow base may do little harm to a Polyzoon on which it is growing. But the effects of an encrusting species would be different, since the orifices of the colony which is being overgrown would be occluded, and the polypides entirely cut off from the outer world. Although experimental evidence is at present wanting to prove this view, I have little doubt that the avicularia are specially important in preventing the fixation of the larvæ of encrusting species. The larva is of course very vulnerable, and it cannot become the founder of an adult colony unless it can find a secluded spot in which it is safe from undue disturbance during the critical time of its metamorphosis. The avicularia are well adapted by their form for warding off larvæ. Those that have the so-called "duck-billed" or "spatulate" form are in many cases large enough to catch or crush a larva without difficulty, while those which have a mandible terminated by a spike-like projection must be even more destructive to the life of any minute organism which is so imprudent as to stray within their reach. In some of the avicularia belonging to this latter type the mandible is strongly compressed along the greater part of its length, and may then assume the shape of a knife-blade, with a sharp cutting edge and a thicker back. The blade shuts down into the calcareous rostrum of the avicularium in such a way that its action may be compared to that of a pair of scissors. It cannot be doubted that this form of avicularium has a high protective value.

In some cases the mandibles or the opercula are toothed. The teeth are specially strong in certain species of the genus *Steganoporella*, where the opercula become most formidable weapons. The large development of the occlusor muscles proves that the closure of these opercula must take place with much force.

The protective value of the avicularia may be illustrated by the distribution of these organs in *Retepora*, the species of which usually grow in the form of a calcareous network, with oval meshes or "fenestræ" between the branches. These are furnished with an elaborate armature of avicularia, which usually occur in large numbers and in considerable variety of form and size. Some of them are scattered over the front surface, on which alone the zoecia open, while others occur on the more unprotected backs of the branches, where there are no zoecial orifices. To guard against an attack from the rear the margins of the fenestræ are frequently furnished with avicularia, among which some are usually of a specially large size,

and are well situated to intercept any larva or adult animal that might attempt to pass through a fenestra.

A healthy *Retepora* is usually completely free from encrusting organisms in regions where the avicularia are functional. One of the few exceptions I have noticed to this rule is specially instructive. In this case a small encrusting Cheilostome colony is growing near the edge of the *Retepora* frond. The primary individual or ancestrula of the encrusting colony is readily distinguishable, and its position shows that the larva from which it was formed must have attached itself to the growing margin of the *Retepora*, a region in which the avicularia were not fully formed. Having thus established itself, the colony has succeeded in invading a small region of the adjacent parts where the zoecia are still vigorous and healthy. A dead *Retepora*, on the contrary, forms a substratum which is well adapted for the growth of various organisms, such as other Polyzoa, Sponges, Hydroids, Compound Ascidians, and Foraminifera.

Although the avicularia are thus effective in preventing the overgrowth of the colony by most of the organisms that might otherwise settle there, there are one or two animals of suitable habit which have succeeded in establishing themselves in the very midst of the defensive works. In species of *Retepora* from the Malay Archipelago¹ I find that a considerable proportion of the colonies are infested by a Gymnoblasic Hydroid of *Syncoryne*-like appearance. The association of this with its host is so intimate that the hydroid becomes completely included in tunnels formed in the calcareous mass of the Polyzoon, where it is, of course, safe from the avicularia. These tunnels, the walls of which are secreted by the Polyzoon, open to the exterior by tubular apertures situated on the margins of the fenestræ and on other parts; and they are so definite in their appearance, and often so regularly arranged, that it might be difficult to believe that they were not a normal feature of the *Retepora* were it not possible to demonstrate their relation to the Hydroid.²

There is one other organism which has a definite relation to colonies of *Retepora* in Malay waters. This is *Loxosoma*, a stalked Polyzoon which leads a practically solitary life owing to the fact that its buds break off as soon as they have reached maturity. The *Loxosoma* no doubt succeeds in enjoying a secure existence, even though it is surrounded by avicularia, owing partly to its stalked form and partly to its minute size. It is commonly found in considerable numbers, and often attaches itself in such a way that it projects into one of the fenestræ, where it is as far as possible removed from the dangerous neighbourhood of the avicularia.

We have thus seen that, while the species of *Retepora* are adequately protected against many encrusting or epizoic organisms, there are one or two animals that have succeeded in evading the attacks of the avicularia, which, it must be remembered, are rigidly attached to the colony, and cannot go in search of any enemy that keeps out of their way. The efficient avicularian protection may well be responsible for the fact that *Retepora* is a common and widely distributed genus, flourishing in both shallow and deep water. Not only is it found in large numbers in the most diverse localities, but it has differentiated itself into a large number of species, among which avicularia occur in great profusion and in a great variety of forms. But so soon as the avicularia cease to be active we find that numerous organisms settle on the unprotected branches; and a dead colony of *Retepora* is accordingly usually found to be invaded by numbers of other animals.

One other familiar case may be mentioned illustrative of the means by which a Polyzoon may be protected from

¹ The greater number of the facts referred to in this Address have been observed during my study of the Polyzoa collected during the *Siboga* expedition.

² It may be noted, as has already been done by Alcock ("Ann. Mag. Nat. Hist.," ser 6, x., 1892, p. 207), that many other cases are known in which there is an association between a Gymnoblasic Hydroid and some other animal. The interesting case of the association of a Gymnoblasic Hydroid (*Stylactis*) with a fish (*Minous*) described by Alcock has also been described, more recently, by Franz and Stechow (*Zool. Anzeiger*, xxxii., 1908, p. 752). Another case of the association of a Cœlenterate with a Polyzoon has been recorded by Haswell and by Kirkpatrick, who have called attention to the occurrence of a small "Actinid" which forms definite cavities in a massive calcareous Cheilostome from Australian waters. There is in this case no satisfactory evidence to show what the Cœlenterate really is.

encrusting organisms, and at the same time of the success with which certain animals have ignored the defensive works that are effective against ordinary foes. This is the common *Flustra foliacea* of our own shores, in which, although avicularia are present, the defence is provided largely by the numerous stiff spines which make its surface irregular, and thus unsuitable for the growth of an encrusting organism. But certain delicate Polyzoa, such as *Crisia* and *Scrupocellaria*, which are attached by fine rootlets, flourish on this species, their rooting processes being able to adapt themselves to the irregularities of the surface, and to escape the closure of the opercula and mandibles. A Gymnoblasic Hydroid (*Hydranthea margarica*) of a similar mode of growth is also known to occur on healthy colonies of *Flustra foliacea*.

In a large number of erect Polyzoa the colony, or zoarium, assumes the form of a small branching tree-like growth in which, as in *Retepora*, the zoecia open on one surface only of the branches. The opposite surface is often devoid of any armature of avicularia or vibracula, a fact which at first sight seems opposed to the view that these structures are protective. But I think that in some of these cases the form of the zoarium affords an answer to this objection, since the branches are so crowded that the avicularia of the front surface of one branch are probably quite capable of affording protection to the backs of the nearest branches. It may be noted that *Scrupocellaria* and *Caberea*, in which vibracula occur on the backs of the branches, usually have a much laxer mode of growth than *Bugula*, in which the back is unprotected.

In some other erect species there are no avicularia at all. But here we often find, as in *Euthyris*, that the whole of the frond is covered by an organic membrane, the "epithecæ," which invests the calcareous parts; and it seems to me probable that this epithelial layer is itself protective. Schiemenz has shown that it is an advantage to certain Molluscs to have an internal shell, since Starfishes can devour Molluscs to the shells of which they can attach their tube-feet, while they can obtain no hold on the slimy surface of a Mollusc which has covered its shell by part of its soft tissues. Although the enemies to be guarded against are not the same in the Polyzoa, there may, none the less, be an advantage in having the calcareous parts covered with an organic membrane. The species which are especially liable to the attacks of *Folliculina* appear to be those in which the calcareous parts are but little protected, as in *Cyclostomes* such as *Lichenopora*; while this Infusorian readily establishes itself on dead parts of *Cheilostomes* which have lost the epithecæ that covers their active regions. The encrusting species of Polyzoa doubtless prefer a hard, calcareous surface on which to grow to a soft, yielding membranous surface.

As a further factor with which the absence of avicularia may be correlated may be mentioned the shape of the individual zoecia. There are many cases, such as *Schizoporella cecilia*, *Mucronella ventricosa*, and a number of others, in which the zoecia of a species devoid of avicularia are very convex in their external shape. The conjunction of a succession of convex zoecia is probably important in preventing the encroachments of encrusting species, which more easily adapt themselves to a level surface than to one which is strikingly uneven or irregular. This is analogous to the case of *Flustra foliacea*, which we have already noticed, where the protection appears to depend largely on the development of spines. The irregular surface of many *Cyclostomes*, which is due to the projection of the free ends of the zoecia, is probably similarly effective in preventing overgrowth by foreign organisms.

In the vibraculum the part that corresponds with the mandible of the avicularium has been prolonged into a thread-like structure, the "seta," which is moved by muscles corresponding with those of the avicularium.

The setæ of *Caberea* are very large, and they close into oblique grooves which run along the back of the branch. The protective value of these setæ is well shown in a specimen I have observed from Torres Straits, in which a minute encrusting *Cheilostome* has formed a single row of zoecia along the region between two of the vibracular grooves, but has not extended into any part where it would be subject to injury by the movements of the setæ.

The vibracula are, however, probably used for other

purposes besides the protection against living foes. They no doubt serve to brush away foreign particles which might otherwise settle on the surface of the colony and block up the orifices. This function has been suggested for the vibracula of the so-called *Selenariidae*, a group of forms which agree in having a zoarium of a discoidal or inverted saucer-like shape. The colony is believed to rest freely on the bottom, on the edge of its concave base, though I have some evidence that it may be attached to the ooze by means of very delicate, flexible, rooting processes. Some at least of these *Selenariiform* species occur in situations where the ground is covered by *Globigerina* ooze, the settlement of which on the convex surface bearing the orifices is probably prevented by the vibracula. It is now generally admitted that his type of colony has been independently acquired in several cases, the so-called family being, in fact, an entirely unnatural assemblage of genera. It may be worth while to point out in passing that I have noticed in several cases that the *Selenariiform* colony commences its existence on a Foraminiferan shell or other minute object, in the absence of larger surfaces on which fixation can be effected, and that the characteristic discoidal form is due to the growth of the circular edge of the colony beyond this initial supporting base.

But my object in introducing this group of *Cheilostomes* at the present point is to direct attention to the relatively enormous size which is reached by the setæ of the vibracula of some of the species, a size which is so great that it has even been supposed that these appendages are used as oar-like organs of locomotion. In a specimen of *Selenaria hexagonalis*, from South Australia, in the Museum of Zoology at Cambridge, the setæ have been colonised by a minute *Cheilostome* belonging to the genus *Eucratea*. It might be said that in this case the setæ have almost over-reached themselves, since they have become so large and powerful that another species is minute enough to find a home on the protective mechanism itself.

Having thus dealt with the probable functions of the avicularia and vibracula, we may now return to the consideration of the forms assumed by these appendages and of their distribution in the colony. The protective function which they appear to possess prepares us for finding, as is actually the case, that they are modified in an extraordinary number of directions. But although they occur, in one form or another, in the majority of *Cheilostomes*, they may be completely absent in an entire genus, in certain species of a genus, in certain varieties of a species, or in individual colonies of species which normally possess them. They are often wanting on some of the zoecia, though present on most of the zoecia, of a colony; and they may vary to a considerable extent in the position they assume on the zoecium. Not only are they thus variable in their occurrence, but they show equally striking differences in their individual characters. They may be all of one kind in a single species, or two or more kinds may occur distinguished by size, by the shape of the rostrum and mandible, or in other ways. We thus come to the consideration of the question how far these appendages can be used in the discrimination of species.

The characters on which species are founded in a group of colonial animals like the Polyzoa obviously differ in certain respects from those which are used in distinguishing species in organisms that lead a solitary existence. In the colonial forms we are concerned partly with the mode of association of the individual units, partly with the manifestations of dimorphism or polymorphism shown by those units and partly by the features of the individuals themselves. Among the *Cheilostomatous* Polyzoa the dimorphism or even polymorphism of the individual, due to the presence in the colony of avicularia and vibracula, is of special importance.

While the characters of the avicularia have accordingly long been used by systematists for distinguishing species, no one—so far as I am aware—has hitherto suggested any hypothesis which helps us to form a reasonable conception of the significance of the innumerable modifications undergone by these organs; nor do I think that the problem has ever been fairly stated.

The difficulty of understanding the evolutionary significance of the avicularia arises in part from the fact that the occurrence and distribution of these structures appear

in many cases to give but slight indications of affinities. It cannot, for instance, be assumed, without further evidence, that two species possessing an identical type of avicularium are nearly related. The complete absence of avicularia in a particular species is no sufficient reason for removing that species from an assemblage of forms in which avicularia are always present. And, lastly, there may be good grounds for believing that two forms with entirely different types of avicularia are closely related, and in some cases may even belong to the same species.

The result of a comparative study of the Cheilostomata leads, in fact, to the conclusion that although certain genera or species are characterised by the possession of one or more definite types of avicularium or vibraculum, other genera or species show no such constancy in this respect. The occurrence of the same type of avicularian appendage in the species of widely separated genera and the diversity of type of avicularium within the limits of a single genus or species render it most difficult to frame any theory that will account for the facts. Are we to assume that a given type of avicularium has been evolved independently in a number of cases, or must we suppose that species with that type have inherited it from a common ancestor? If the latter hypothesis be the correct one, we seem to be led to the conclusion that the ancestral Cheilostomes were provided with most of the types of avicularia that actually occur in existing species, many of which have lost one or more of those types.

In trying to arrive at some conclusion with regard to these points we may notice, in the first instance, one fact which stands out with great distinctness—namely, that, whatever the modifications of the avicularium may be, the mandible is usually either acutely pointed at its free end or rounded and spatulate at its termination. The difference may at first sight appear unimportant, but I am inclined to believe that it is an indication which may lead us to results of great significance.

Though it may be going too far to assert that all avicularia belong to one of these two types, there is usually no difficulty in recognising either the pointed or the rounded character in every avicularium present on a colony. The distinction may be observed by inspecting the form of the rostrum in a dry preparation of a part of the zoarium, but it is seen with more certainty when the mandibles have been isolated and are examined in Canada balsam. So striking is the difference that the inquiry naturally suggests itself whether there is any indication of the evolutionary meaning of the two kinds of avicularium. It appears to me probable that a condition which is characteristic of the existing genus *Steganoporella* may furnish the answer to this question. In this genus avicularia are typically absent, but in each species the zoecia are of two kinds, distinguished by differences in the shape and structure of the opercula and orifices. The anatomy of the zoecia is known in but few cases, but in those that have been observed both kinds of zoecia possess polypides. In one division of *Steganoporella* the more differentiated zoecia show some resemblances to the pointed type of avicularium, while in a second division they more nearly resemble rounded avicularia. I am inclined to believe that these conditions correspond respectively with the two kinds of differentiated avicularia of other Cheilostomes.

The avicularia most commonly met with occur as appendages of the ordinary zoecia, which alone constitute the main framework of the colony. But in addition to these, the "adventitious" avicularia of Busk, we find, although less commonly, another kind known as the "vicarious" avicularium, from the fact that it occupies the place of an ordinary zoecium, with which it agrees more or less closely in point of size. Its mandible is usually of the rounded type, appropriately referred to as "duckbill-like," and is readily seen to represent the operculum of an ordinary zoecium. Compared with this the mandible and the orifice which it closes are greatly enlarged, while the occlusor muscles have become correspondingly increased in size. The polypide is generally absent in the vicarious avicularium.

Pointed avicularia of the vicarious type occur normally in the species of *Onychocella*, which, alike by their structure and by their early palæontological appearance, may

be regarded as representing a primitive type of the Cheilostomata. Vicarious avicularia with a rounded mandible occur in certain species which I refer provisionally to *Siphonoporella*, as well as in a small proportion of the species of *Membranipora* and *Flustra*. All these may fairly be regarded as belonging to a comparatively undifferentiated type of Cheilostomata, and their vicarious avicularia are usually the only ones present. It is thus not improbable that the avicularium in these cases really represents an early stage of evolution. But we must notice that precisely similar rounded vicarious avicularia make their appearance occasionally in species of a much more differentiated type, as in the well-known *Schizoporella Cecilii*¹ and in certain other species which may for the present be referred to the same genus. In the majority of the very numerous species of *Schizoporella* vicarious avicularia are not known to occur, and it is thus impossible to regard them as a typical attribute of the genus.

The vicarious avicularia, which by their position and general structure are so easily comparable with the ordinary zoecia, are usually supposed to represent an initial stage in the evolution of the avicularium. But if this view be correct, how are we to account for the sporadic way in which these structures occur in a series of genera such as *Membranipora*, *Flustra*, *Schizoporella*, and *Cellepora*, the last two of which, at any rate, are highly specialised in other respects? What conclusion can we draw from the association, in one and the same colony, of this type of avicularium with adventitious avicularia of the most specialised description? How can we explain the fact that each kind of avicularium occurs in certain species, but not in all the species, of many distinct and not specially related genera? And, lastly, what is the significance of the fact that certain species of a genus which is normally provided with avicularia may be totally destitute of these organs? These are some of the problems of which no satisfactory solution has at present been given. On the ordinary view of the way in which the species of a genus are interrelated we should perhaps not expect to find that two species which are closely similar in other respects may be distinguished by possessing entirely different types of avicularia.

I am aware of the fact that it is perhaps premature to indulge in speculations which are unsupported by experimental evidence. But it appears to me worth while to suggest that some of our difficulties might be removed by appealing to the results obtained by workers on Mendelian inheritance. An essential part of the theory here involved is that in the formation of the gametes of an organism there is a segregation of certain paired or "allelomorphic" characters whereby some of the gametes are endowed with qualities by virtue of which they transmit one of the characters, while the rest of the gametes become capable of transmitting the characters of the other member of the allelomorphic pair. It has recently been made probable by Prof. Bateson, whose views have been confirmed by others, that the actual appearance of a particular character may be dependent on a coupling of two allelomorphs belonging to distinct pairs. If only one of them is present the character will not show itself. The phenomenon of reversion on crossing is thus explained as due to the combination of allelomorphs present in the isolated condition in two parental forms.

Is it not possible that the perplexing occurrence of vicarious avicularia in some of, but not by any means in all, the colonies of certain species may be interpreted as a reversion due to the combination of two or more allelomorphs that may not have occurred together in the parental forms? We have seen that there is some reason to believe that these avicularia are really of an archaic character, from their occurrence in certain genera of a primitive type, known in some cases by palæontological evidence to have appeared early in the evolution of the Cheilostomata. We may further remember that we have distinct evidence that Cheilostomes of a differentiated type may retain certain primitive characters, in the occurrence of a *Membranipora*-like form of ancestrula in so many of them. If, then, we may suppose that the appearance of vicarious avicularia is due to a combination of more than one allelomorphic we may recognise the possibility that the

¹ Kirkpatrick, "Ann. Mag. Nat. Hist." (6), v., 1890, p. 21.

ancestrulae of a given species still carry the determinants representing those allelomorphs. In species in which the vicarious avicularia are of normal occurrence there is no difficulty in this hypothesis. In others, of which examples may be found in *Schizoporella*, the vicarious avicularia make their appearance rarely, in a very small proportion of colonies. In these cases the facts might be accounted for on the hypothesis of the chance recombination of allelomorphs which are ordinarily separated, unless, indeed, it should prove to be the case that the vicarious avicularia represent a recessive character which is usually prevented from making its appearance by some dominant factor.

A single series of cases of this kind will not carry conviction, but there are many facts with regard to the distribution of adventitious avicularia that may point in the same direction. We may recur to the fact that the form of these appendages may be eminently characteristic of a whole series of species which from their similarity in other respects are naturally associated in a single genus or family. The most striking instance of this is, perhaps, the genus *Bugula*, in which we find the avicularium *par excellence*. The variations of this type of avicularium are comparatively slight, and for the most part depend on differences in position with regard to the zoecia and on minor modifications of size, shape, and length of stalk. Both in *Bugula* and in the allied genus *Bicellaria* the avicularian characters may be described as relatively constant; and since they belong to a type that is rarely met with in other genera, they seem to confirm the evidence afforded by other structural features that the species which possess them are related to one another. But even in *Bugula*, where the avicularia reach the summit of their development, we meet with species or varieties in which these appendages are invariably absent throughout the colony. This may be illustrated by *Bugula neritina*, a widely distributed species which in the Mediterranean and certain other districts is remarkable for the complete absence of avicularia, although in other structural features it shows a close affinity to other species of *Bugula*. In Australian and Oriental waters, however, there occur forms which can hardly be distinguished from *B. neritina* except by the fact that they always possess numerous avicularia of the specialised character that is so distinctive of the genus. It does not matter for our present purpose whether these are to be regarded as a variety of *B. neritina* or not. If the appearance of avicularia may be regarded, on Mendelian principles, as due to the presence of one or more allelomorphs, it is possible to understand that these may be omitted in certain cases, and that there may thus be a close affinity between two forms, one of which differs from the other in what appears at first sight so essential a respect as the complete absence of the avicularia, which we are justified in regarding as the most important feature of the genus.

A second case of the same general nature may also be noticed. In the family Cellulariidae are included a number of delicate erect species which are commonly placed in the genera *Caberea*, *Scrupocellaria*, *Menipea*, and *Cellularia*. The first two of these are distinguished by possessing vibracula as well as avicularia. *Menipea* is defined as possessing avicularia, but no vibracula; while *Cellularia peachii* does not possess either kind of appendage. A species known as *Amastigia nuda* has been placed in a separate genus because of the absence of vibracula and their replacement by avicularia, while in other respects it agrees with *Caberea*, in which the vibracula reach a development not exceeded by those of any other Cheilostome. Before considering the bearing of these facts we may appropriately consider another instance taken from the same family, although by doing so we are for the moment leaving the question of the avicularia. In the genera *Caberea*, *Scrupocellaria*, and *Menipea* certain species are distinguished by having the free surface of the zoecium protected by a peculiar spine known as the "scutum," which is usually flattened and much expanded at its free end, where it overarches the membranous frontal surface in such a way as to cover and presumably to protect it. But in each genus other species are characterised by the complete absence of the scutum; while in others it occurs in varying degrees of reduction.

We have thus several cases in which certain species

differ from their near allies in the complete absence of a structure which is, as a rule, one of the most distinctive features of the genera to which they are respectively assigned. Should it be possible to prove that the appearance of the organ in question, whether avicularium, vibraculum, or scutum,¹ was of the nature of an allelomorph character, its disappearance would be readily intelligible.

The facts which I have indicated with regard to the so-called Cellulariidae have not hitherto been sufficiently discussed; but I imagine that most systematists who have considered the question have assumed that the scutum, for instance, has undergone parallel evolution in *Caberea*, *Scrupocellaria*, and *Menipea*, either having been independently evolved in each of the three cases (a most improbable supposition), or having independently undergone a series of regressive changes of precisely similar character in the three genera.

But it is perhaps in the mode of occurrence of adventitious avicularia that we find the strongest reason for believing in the existence of some form of alternative inheritance. We may indeed go so far as to assert that alternative development does actually take place, whether the explanation of the facts is given by the Mendelian theory or not. The difference between the pointed and the round avicularia is a very definite one, which—it is no exaggeration to say—may be observed in hundreds of species. When these species are arranged under genera according to the result of a study of the whole of the evidence derived from all the characters that have proved valuable in classification, we find that many genera include some species with one type of avicularium and others with the other type. It should perhaps be pointed out that the validity of many of these genera is a matter on which differences of opinion exist. The subject is undoubtedly a difficult one, and we are far from having arrived at any certainty with regard to the classification of the Cheilostomata. But it is perfectly certain that we could not utilise the two kinds of avicularia in dividing these Polyzoa into two main series, since there are innumerable cases in which both kinds occur in a single colony. This is a fact to which I shall return later.

We may accordingly maintain that, although much is probably faulty in our present system, we have clear evidence that the same genus may include species which differ in the type of avicularium; and, moreover, that these are not exceptional, but, on the contrary, are of common occurrence. A few instances will make these points clear.

In the encrusting species and in certain others the avicularia commonly occur, as we have already seen, in a position near the orifice of the zoecium, where they are usually either lateral or suboral. In one of the species with lateral avicularia these appendages may be of the pointed type, while in another they may be rounded; and the same statement may be made with regard to the suboral avicularia. Within the limits of the same genus we may further notice that certain species have lateral avicularia, while others have suboral avicularia. Here, again, we find the same indifference as to the shape of the rostrum and mandible.

If we might provisionally suppose that the two kinds of avicularia constituted an allelomorph pair, represented by Aa, and that the lateral and suboral positions indicated a second allelomorph pair, Bb, the four combinations, AB, Ab, aB, ab, would be theoretically possible. We might, in other words, have pointed or rounded lateral avicularia, and pointed or rounded suboral avicularia. All these conditions actually occur in such genera as *Lepralia* and *Schizoporella*; and in some cases two species which agree in the form of the avicularia but differ in their position, or agree in the position but differ in their form, appear on other grounds to be nearly related one to the other.

Other cases may be taken from *Retepora*, an instance where we may feel ourselves on comparatively secure ground, since there are strong reasons for believing the genus to be a natural one. The genus as a whole possesses an almost bewildering variety in the form, position, and

¹ The case of the scutum is less striking than that of the other structures under consideration, since conditions intermediate between full development and complete absence are not uncommon.

size of the avicularia, among which, however, we may distinguish the following kinds:—(i) The suboral avicularium, closely related to the orifice and usually termed "labial," because it occurs on what may be described as the lower lip; (ii) frontal avicularia, on some part of that surface of the zoecium which bears the orifice; (iii) basal or dorsal avicularia, on the backs of the branches; (iv) fenestral avicularia, which guard the edges of the fenestræ or meshes of the colony.

In many of the species of this large genus the suboral avicularia are of the small rounded type. In other species they are small and pointed, with an acute mandible; while others are distinguished by possessing suboral avicularia that may be described as gigantic.

Among the frontal avicularia similar differences exist. In one case that has come under my observation a remarkable variation of this kind is found within the limits of a single species. Remembering the great difficulty there often is in arriving at certainty with regard to the limits of the species in the genus under consideration, I wish to emphasise the fact that this instance is taken from *Retepora phoenicea*, a form that not only has well-marked specific characters of the ordinary kind, but is remarkable in having a beautiful carmine-red or violet colour, a respect in which it differs from most of its nearest allies. The frontal avicularia of this species are usually of the pointed type, but in the variety in question—a colony from Torres Straits—they are, so far as I have been able to ascertain,¹ all of the rounded kind.

The fenestral avicularia show a similar behaviour. In South Australian waters there are a number of forms which are regarded as varieties of *Retepora monilifera*. In the form known as var. *munita* there is usually a suprafenestral avicularium of large size, distinguished by having a rounded mandible, which is a good deal broader than it is long.² In another form of the same species, distinguished by MacGillivray as var. *acutirostris*, the *munita*-avicularium may either occur as such in some of the fenestræ, or be replaced in others by a large avicularium of the typical pointed form.

In other species a gigantic infrafenestral avicularium commonly occurs, but while these structures are found in a considerable proportion of the fenestræ of some colonies they appear to be completely absent in other colonies. In this series of cases, which is well illustrated by *Retepora phoenicea*, I think there is clear evidence that different colonies, from the same locality and belonging to the same species, may show the two conditions of presence and absence respectively of fenestral avicularia. According to the ordinary criteria by which species of Polyzoa are discriminated, it might be necessary to place these in different species—a result which is not supported by other evidence. I think we must conclude that a species may have the faculty of entirely dropping out some complete series of organs, like certain kinds of avicularia. The Mendelian principle may here come to our aid by showing the theoretical possibility of having the two conditions represented in a series of colonies of identical parentage. If this should really be the explanation of the facts, it should occasion no surprise if some members of the immediate progeny of a colony in which a certain type of avicularium is absent should be found to be provided with a complete armature of these appendages.

The cases so far considered may conceivably be explained on ordinary Mendelian lines by assuming that an entire colony is homozygous or heterozygous with regard to particular characters. Remembering that the so-called ancestrula, or primary individual, does not show all the characteristics of the mature colony, we must, however, assume that the determinants present in it do not find their full expression until the budding process has commenced.

But we are by no means at the end of our difficulties, even in considering the distribution of the appendages we have so far discussed. The instances already given have

for the most part been cases in which an entire colony differs in certain respects from other colonies. We have still to notice the common case in which there are differences in different parts of one and the same colony. No theory can be considered complete unless it is able to account for these differences.

I approach this part of the subject with great trepidation, conscious as I am of the absence of experimental evidence for the suggestion I wish to make. This suggestion is, briefly, that if a segregation of characters normally takes place in the formation of the gametes of an organism, it is conceivable that an analogous segregation may occur in the blastogenic processes, or, in other words, in the formation of a bud. It may be asserted positively that there is a very definite differentiation of individuals at this time, not only in the Polyzoa, but also in other animals which increase by budding. The fact that some of these differentiations appear to be alternative suggests the possibility that they are due to a process which resembles the Mendelian segregation of determinants in the gametes.

One of the instances which appears to me specially suggestive in this connection is the genus *Steganoporella*, the species of which are remarkable for the dimorphism of their zoecia. This dimorphism is expressed, as we have already seen, by differences in the opercula and in their muscles, and in the form of the orifices which are closed by the opercula. It is not too much to say that every individual in a *Steganoporella* colony belongs to one of the two types in question; and, so far as I am aware, intermediate forms of zoecium do not occur. It is thus a positive fact that the blastogenic tissues undergo some sort of differentiation of an alternative character, and there is at present no reason for believing that the differentiation is in any way correlated with the production of sexual cells by either of the two kinds of zoecia.

Another case which seems to me specially suggestive is that of the simultaneous occurrence in the same colony of two different kinds of avicularia. These instances are not confined to a few species, but may be found in a number of genera which do not constitute a single assemblage of related forms. The pointed and rounded adventitious avicularia may be scattered about promiscuously in the same colony, or even on the same zoecium. Sometimes avicularia of one of the two types normally occur in a particular position, but are occasionally replaced by avicularia of the other kind, an example of a general phenomenon to which Prof. Bateson has given the name of "homœosis."

Excellent illustrations of this substitution may be taken from the genus *Retepora*. In the *R. monilifera* series already considered, the *munita* and *acutirostris* types of avicularia may occur in different fenestræ of the same colony. *R. granulata* usually possesses a labial avicularium and a frontal avicularium, both of the small rounded kind. In one of the colonies of this species dredged by the *Siboga* most of the labial avicularia are of this type, but a certain proportion of the zoecia have a pointed labial avicularium. In another colony most of the frontal avicularia are small and round, but in some of the zoecia they are large and pointed. In both instances the examination of the mandibles proved the reality of the distinction inferred from the shape of the calcareous parts.

Instances of a similar substitution could easily be multiplied, while the cases of the simultaneous occurrence of the two kinds of adventitious avicularia are innumerable. Without going so far as to say that intermediate conditions do not occur—a generalisation that could only be established by very prolonged study—it may certainly be maintained that it is the general rule for an avicularium to assume one of the two types. In a suitable preparation it is usually quite easy to sort all the mandibles into their proper group at first sight, and without having to pause to consider doubtful cases. This fact is surely significant, and it can at least be argued that in the blastogenic processes by which the avicularia have been developed some differentiation or segregation must occur by which the two kinds are constituted. If this differentiation should prove to be analogous to the segregation which occurs during the formation of gametes we should be able to account for much that is at present perplexing in the polymorphism of the Cheilostomata. We should in par

¹ It may be noted that it is extremely difficult and often impossible to make a study of every part of a large and irregular *Retepora* sufficiently exhaustive to justify one in asserting positively that all parts are identical in respect of their avicularia.

² This characteristic *munita*-avicularium is probably merely an enlarged form of the small circular type of avicularium met with as labial avicularia and in other positions in many species.

ticular not be precluded from regarding a colony with avicularia of one type as nearly related to other colonies which possess avicularia of the other type; and we should have some explanation of the fact that many of the genera possess all the different forms of avicularia which are variously distributed among their constituent species.

I have so far spoken as if the adventitious avicularia belonged to two types only. This statement requires some further qualification, although it may nevertheless be true that all the forms can be referred to one or other of the two principal kinds. As a matter of fact, a single Cheilostome colony may bear more than two sorts of avicularia; as, for instance, appendages with large pointed mandibles, in addition to two kinds of those with small rounded mandibles.¹ This introduces a further complication, about which it is unnecessary to speculate at present.

It may naturally be asked whether there are any numerical facts which support the suggestions I have made with regard to the significance of the different forms of avicularian appendages. I must admit that the numerical relations are so complicated and apparently so variable that I have not been able to draw any definite conclusion from them.

Experimental evidence is at present wanting, nor would it be easy to devise crucial tests. Even if it were possible to experiment with two colonies of the same species which differ in their avicularian appendages, the result might be negative, since it is not possible to say definitely whether the eggs of a given colony are normally fertilised by the spermatozoa of the same colony or by those of a different colony. Some light may conceivably be obtained from observations on the regenerative processes which may occur in Polyzoa. A recent Paper by Levinsen² gives some information with regard to this point, and there are a few other observations on the same subject scattered through the literature of the Polyzoa.

It is thus obvious that the speculations in which I have permitted myself to indulge cannot be regarded as more than a guess as to the significance of the causes which underlie the facts observed; but, whether the view I have outlined has anything to recommend it or not, the observations on which I have depended are, I think, correct. If this be the case, some explanation of the facts is urgently required. The decision of the principles on which the Polyzoa should be classified may not be a matter of immediate practical importance, but our theories of species cannot be regarded as established until they have shown themselves capable of explaining all the cases. Some modification of the Mendelian theory seems to me to be capable of elucidating the apparently haphazard way in which the several forms of avicularia are distributed in the species of Cheilostomata, and it may perhaps be allowed to afford a working hypothesis that can be used in systematic study. The results of such a hypothesis would, I think, be far-reaching. Whether we are justified in accepting it provisionally or not, I am convinced that we require some hypothesis by which we may regard two specimens as belonging to the same species, even though they may differ in what might at first sight seem to be fundamental respects. And, *vice versa*, we require the liberty to regard two species as widely separated from each other in the system, even though they possess identical types of avicularia.

There are other questions which might have been considered in the Cheilostomata, and, in particular, the presence or absence of oral or marginal spines and the forms and distribution of the ovicells. The occurrence of the latter is, however, probably connected with the presence in the young zoecium of tissue which will give rise to an ovary; and this implies the consideration of another factor which is very difficult to estimate.

¹ In the species of Retepora, for instance, there may occur the following types of avicularia, in addition to others that need not be mentioned: Conspicuously large avicularia, some of which are usually fenestral, either pointed (*a*) or rounded (*b*); small avicularia, either pointed (*c*) or rounded, these latter occurring as two well-marked types in which the mandible is respectively longer than broad (*d*) or broader than long (*e*). The following combinations may occur in individual species or colonies: *a+c+d*, *a+d+e*, *a* alone, *b+c*, *b+d*, and others. Examples of some of these combinations may be seen in Busk's Report on the Polyzoa collected by H.M.S. Challenger (Part XXX., 1884).

² "Sur la Régénération totale des Bryozoaires," Acad. Roy. des Sci. de Danemark, Bull. de l'Année 1907, No. 4.

I must not conclude without at any rate referring to the fact that the Polyzoa are by no means the only animals in which dimorphism or polymorphism occurs as the result of blastogenic processes. But among the Coelenterates, for instance, the occurrence of medusoid individuals cannot be considered apart from the question of the sexual cells. There is, however, one series of cases among Hydroids to which allusion may perhaps be made. I refer to the existence of pairs of genera such as Corymorpha and Tubularia, Syncoryne and Coryne, Podocoryne and Hydractinia, in each of which pairs the two genera are distinguished by the fact that one produces free medusæ while the other has sessile gonophores. There is already some evidence that the validity of these generic distinctions is open to question; and the free medusoid individual and the sessile gonophore might conceivably be related in such a way as to form members of an allelomorphic pair. The same phylum contains another striking example of dimorphism in the distinction between gastrozooids and dactylozooids in many Hydroids; while in the Siphonophora the differentiation of various forms of individual has advanced much further.

But I have already gone much beyond my evidence, and I must bring my remarks to a conclusion by expressing the view that the causes which regulate the differentiation of the individuals during the blastogenic development of the Polyzoa are well worthy of further study, and that our knowledge of the unity of the vital processes throughout the animal kingdom gives us reason to believe that they are part of some general Biological law.

SECTION E.

GEOGRAPHY.

OPENING ADDRESS BY MAJOR E. H. HILLS, C.M.G., R.E.,
PRESIDENT OF THE SECTION.

THE thirty years that have elapsed since the British Association last met in this city of Dublin have seen an obvious and rapid progress in the science of geography, and a steady though perhaps not quite so apparent change in the character of that science.

In 1878 large parts of the earth's surface still remained untrodden by the feet of a white man; large areas were open to the enterprise and intrepidity of the explorer; large spaces were blank paper upon our maps. Now there is but little of the earth's surface absolutely unknown.

It is not my intention to detain you by any recapitulation of the work of these years to show you how and by whom these areas have been traversed and the gaps in our maps filled in. I intend rather to speak of the present and of the future work of the geographer, and to do this to any advantage we must at the outset recognise the change that has taken place in the nature of his task, and the fact that the days of individual exploration are over, never to return. We must recognise that sporadic, unorganised effort must be and is being replaced by organised, systematic work, and that the scientific traveller of the last century, with his rough map-making equipment, his compass, watch, and sextant has yielded his place to the scientifically equipped survey-party with their steel tapes, theodolites, and plane tables.

The theme is not a new one to this Section. I find on referring to the transactions of past years that in 1902, at the Belfast meeting, Sir Thomas Holdich, the President of Section E, said: "We find those spaces within which pioneer exploration can be usefully carried out to be so rapidly contracting year by year as to force upon our attention the necessity for adapting our methods for a progressive system of worldwide map-making, not only to the requirements of abstract science but to the utilitarian demands of commercial and political enterprise."

These words express succinctly the ideas that I wish to take as the text of my address to-day. I am, however, not ambitious enough to attempt to cover the whole surface of the earth in the brief review that I intend to put before you of the progress of scientific survey. Rather I wish to restrict our outlook to that section of the work in which we may all be considered as having a direct personal interest—namely, the survey of the British empire, especially those lands under the more immediate tutelage of the

Government of this country. Let it not be thought, however, that while we for the moment pay little attention to the regions lying outside this definition, we are supporting the fallacious idea that the survey of any part of the earth can be considered apart from the survey of the surrounding country. With the possible exception of the case of an oceanic island such an assumption would be an erroneous one. Our British empire is so widespread and our possessions are so often in close and intricate juxtaposition with those of other nations that there is in this work large scope, and indeed necessity, for international co-operation. Examples of this will occur to us in the course of our review. We shall thus see that in addition to the obvious connection which the geography of our empire has with that of other countries there is an even closer connection in the methods of manufacture of that geography, which methods we summarise under the general term of survey. One of the root ambitions of the scientific surveyor is to determine the exact figure of the earth, an operation for which observations spreading over a large area of the earth's surface are demanded. In fact, we may truly say that the problem of the earth's shape will not be completely solved until the whole surface is known to the surveyor. That is, therefore, pre-eminently a problem for international solution.

Before proceeding to the consideration of our special subject, the survey of the British empire, it will be interesting to interpose a few remarks on the questions of the utility and origin of national surveys in general. We may first note the somewhat curious fact that the production of a map of a country, useful as such a work is for many purposes, has almost always been embarked upon because the imperative necessity of maps of the theatre of operations in war has been brought home to the people and Government of a nation. Thus the ordnance survey of England had its first beginning in a military map of the highlands of Scotland, commenced in 1747, intended to facilitate the operations of the troops under the command of the Duke of Cumberland. It was not until many years later that the systematic triangulation of the country was undertaken, a work which was initiated partly for map making and partly for astronomical purposes. There was a consensus of opinion among astronomers that it would be greatly to the advantage of that science if the observatories of Greenwich and Paris could be connected by triangulation, and the famous French astronomer Cassini, in October, 1783, drew up a memoir to this effect. The arguments brought forward convinced King George III., and he granted a sum of money sufficient to enable the work to be started. This act of royal generosity was recorded by the surveyors in the following grateful terms: "A generous and beneficent monarch, whose knowledge and love of the sciences are sufficiently evidenced by the protection which he constantly affords them and under whose auspices they are daily seen to flourish, soon supplied the funds that were judged necessary. What his Majesty has been pleased to give so liberally it is our duty to manage with frugality consistent with the best possible execution of the business to be done."

It is worthy of remark that the junction of the triangulation systems of Great Britain and France was not made until 1861, and that the trigonometrical connection of Greenwich and Paris observatories has not yet been completed to the final satisfaction of men of science, a point which we shall have occasion to recur to later.

In France, we may note in passing, the starting of the triangulation had a quite different and quite definite object, the determination of the length of the metre. This unscientific unit of length was fixed as a fraction ($1/10,000,000$) of the quadrant of the earth's surface between the Pole and the Equator, and to find this quantity it was necessary to measure on the earth's surface as long an arc of the meridian as could be obtained.

In the case of our other great national survey, that of India, its origin is to be found in circumstances somewhat analogous. The Madras Government, owing to the success of the British arms in the Mysore campaign, found itself with a great accession of totally unsurveyed country in the middle of the Peninsula, while at the same time there were only in existence the roughest sketch-maps of the older possessions. It was apparent that if any map, of

even approximate accuracy, was to be made covering a country of such vast area, it was imperative that the work should be prosecuted upon the most rigorous and strictly scientific basis. The general lines upon which it should be undertaken were laid down in February, 1800, by Brigade-Major Lambton, who addressed a letter to the Madras Government advocating a mathematical and geographical survey of the peninsula.

In this letter he discussed the principles upon which such a survey should be based. He dismissed astronomical fixations as not providing the requisite degree of precision, observing that such determinations of position are liable to great inaccuracies, "three, four, perhaps ten minutes," and proposed a triangulation emanating from a measured base line checked by similar base lines at intervals. He recognised that the figure of the earth and lengths of the polar and equatorial radii were not then known with the precision necessary for fixing the spheroidal co-ordinates of the trigonometrical stations of a survey covering such a large area of the earth's surface, and that a geodetic survey was therefore necessary *pari passu* with the geographical survey. He had an impression, how derived it is not now possible to say, that there was a sudden abnormal diminution of the force of gravity at the latitude of 10° north, and consequently that "a degree on the meridian from that parallel to the Equator must be very short compared with a degree to the northward of 10° ." He observed that it would be necessary to "attend to this circumstance," which he characterised as important both from the map-making and from the rigorously scientific point of view. He added: "I shall rejoice, indeed, if it should come within my province to make observations tending to elucidate so sublime a subject."

In a similar case, occurring in recent years, the outcome has not been so satisfactory. It will be within the recollection of all here how at the time of the South African war the public at home learnt with shocked surprise that there were no maps in existence of a colony which had been under the British flag for a long period of years. To those who knew the facts this was, naturally, no matter of surprise; but it was earnestly hoped by many that this grave deficiency thus revealed by the stress of war would be remedied by quiet work in the time of peace, and that, at the conclusion of the military operations, the foundation should be laid for a federal survey department of British South Africa comparable with, though on a more moderate scale than, the Survey Department of India. This hopeful scheme, which it may be recorded very nearly came to fruition, ultimately found political conditions too adverse, and had to be indefinitely postponed. An army engaged in field operations in the north of Natal now, or, in fact, at any time for an indefinite number of years in the future, would find the country nearly as mapless as it was found by Sir R. Buller in 1900.

In this short recital of the determining causes which have in the past led to the initiation of national surveys, it will have been noticed that no allusion has been made to what we should now perhaps consider the main utility of a map—namely, its value for all purposes connected with the ownership, development, and taxation of land. When the ordnance surveys of Great Britain and Ireland were originated there was little thought of this use, and it was not until long after that period, when the enormous deficiencies of the existing property plans were revealed by the Tithe Commutation Acts and by the railway boom, that the value of a national survey for preparing a cadastral or large-scale property map of the country was recognised and acted upon. Now this is often the ostensible object for embarking upon a regular survey. It is fully recognised that, especially in the case of a country undergoing rapid development, which is fortunately true of many of our oversea possessions, the provision of an accurate land map is of prime necessity both to the private or corporate landowner and to the State.

Neither were any of the early surveys undertaken for the purpose of mutual delimitation of international boundaries, a necessity which has in recent years been the stimulating cause for many pieces of valuable survey work, especially in Africa.

The other manifold uses of a map are familiar to all of you, and we need not pause to enumerate them. We

may admit the fact that the adequate mapping of its territories is recognised as one of the duties of a civilised State. Let me now turn to the main subject of this address—the inquiry as to how far this duty is performed by us, what shortcomings we can perceive, and what suggestions we can offer for the future.

Two years ago this task would have been a difficult and laborious one. Now it is greatly facilitated by the issue from the Colonial Office of those excellent little volumes, the reports of the Colonial Survey Committee.

This body has been in existence since August, 1905, and has published three annual reports. The Committee is therein defined as an advisory one formed at the instance of the Secretary of State for the Colonies to advise him in matters affecting the survey and exploration of British colonies and protectorates, more especially those in tropical Africa. It is not at present an executive body, that is to say, it has at its own disposal no grant of public money or other funds; whether it will ultimately develop into such is a question that the future alone can answer. Even thus limited in scope and powers it has, however, already worked a notable improvement—firstly, by laying down authoritatively some of the more salient conditions that ensure the efficient and economical expenditure of whatever funds may be available, and by pointing out the disastrous extravagance of unsystematic and unmethodical work; secondly, by insisting upon uniformity where uniformity is essential, such as in matters relating to the style, projection, scales, and sheet-lines of the maps produced, while leaving the utmost latitude as to methods, these being selected in each case to suit the very divergent nature of the country met with. It results from this that any two small portions of the map of Africa, say, for instance, one sheet of the dense forest region of the Gold Coast and another of highland country of East Africa, though 3000 miles apart and executed at different times by a different staff, will match each other in general character, and will ultimately be found to fit exactly into their places as constituent parts of a great map of the country. Thirdly, we may reckon the mere fact of publicity in these matters as of no mean advantage. Though, as in the case of many other Government publications, this report is not as widely read as its merits deserve, yet it is all to the good that the information is there ready and available for anybody who has the curiosity to consult it. I therefore welcome the opportunity of directing your attention to this volume.

In entering upon the discussion on the survey of British Africa, the first point that meets us is the geodetic basis of the whole work; upon what do the actual positions depend? In other words, to put the matter more familiarly, how are we to provide that every isolated piece of the map will exactly fit into its proper place? The only method for ensuring this is by basing all our surveys, ultimately, upon a skeleton or framework of geodetic or primary triangulation executed with the utmost attainable precision. Such a skeleton, or rather backbone, will eventually exist in Africa in the shape of the meridional arc, or chain of triangles, along the thirtieth meridian, running right through the country from north to south, and ultimately joining on to the great arc observed by the famous astronomer Struve. This originally extended from the mouth of the Danube to Hammerfest, in Norway, an amplitude of $25\frac{1}{2}^{\circ}$ of latitude. To prolong it southward, passing up the Nile Valley, through the heart of tropical Africa, across the Zambezi River, and terminate it at the southernmost point of the continent, is a magnificent conception due to Sir David Gill, to whose energy and enterprise the actual execution of considerable sections of the undertaking must also be ascribed.

At the present time the chain has been completed from the south to within seventy miles of the southern end of Lake Tanganyika, a distance of about 1700 miles. At Lake Tanganyika it will enter into German territory. The German Government, fully recognising that the project is not only of great theoretical interest, but also of immediate practical value, are already taking steps to start work on their own section, from the south of Tanganyika up to the parallel of 1° south latitude. From 1° south, northward to about $1\frac{1}{2}^{\circ}$ north, the arc lies near the boundary between the Congo Free State and the

British Protectorate of Uganda. An International Commission is at present engaged in the survey of the boundary region, and Sir D. Gill, ever ready to seize an opportunity of forwarding the work he has at heart, succeeded in raising sufficient funds, partly from the Treasury and partly by grants from a few leading scientific societies, to enable an observer to be sent out with this Commission to carry the arc over this section. North of this point the line comes into the territory of the British Soudan, and traversing this eventually reaches Egypt proper. Here it comes into the charge of Captain H. G. Lyons, the director of the Survey Department of Egypt, under whose care its interests are safe.

It will thus be seen that while the actual completion of the whole chain is as yet somewhat remote, we are in the satisfactory position of being able to say that, so far as the section lying on the continent of Africa is concerned, there is no portion of which there is not a reasonable probability that it will be finished within a measurable period. With regard to the section joining Africa and Europe the position is not so happy. This will run through Palestine and Asia Minor, and therefore lies in Turkish territory. It is not likely that the Turkish authorities either will or could carry out such a work; in fact, seeing that even when completed it would be totally useless to them, it would be hardly reasonable to expect them to do so. It must, therefore, presumably be a matter for international cooperation. One point may be mentioned with regard to the exact route of this connecting section. Sir D. Gill, in his Report on Geodetic Survey of South Africa, 1896, said: "By an additional chain of triangles from Egypt along the coast of the Levant, and through the islands of Greece, the African arc might be connected by direct triangulation with the existing triangulation of Greece, and the latter is already connected with Struve's great arc of meridian which terminates at the North Cape in latitude 71° N. The whole arc would then have an amplitude of 105° ." This, however, gives rather a poor connection with the European triangulation. The South Albanian series has a much higher average error than either Struve's original work or any part of the African series. This portion would consequently be a weak link in the geodetic chain, and it would be better to avoid it altogether by carrying the line along the coast of Asia Minor to Constantinople, and then up the east side of Turkey to the mouth of the Danube.

When we look back a few years and call to mind the prominent part that this country has taken in the survey of Palestine—I need only mention in this connection the names of Kitchener, Warren, and Conder—we cannot avoid a feeling of regret that we are not ourselves in a position to take the whole execution of this section of the line upon our shoulders. I am too well aware of the many urgent claims upon the Treasury to suggest that it is possible that they would be prepared to incur such a charge; but supposing, for the moment, that part of the necessary funds could be provided from other sources, I think we may fairly urge that it is our duty to contribute a substantial monetary grant towards the furtherance of an end so desirable and so practically useful.

The difficulty of obtaining money for geodetic work, the benefit of which is not immediately apparent to the man in the street, is notorious. Thus Sir T. Holdich, in 1902, said: "But this accurate framework, this rigorously exact line of precise values which ultimately becomes the backbone of an otherwise invertebrate survey anatomy, is painfully slow in its progress and is usually haunted by the bogey of finance. It does not appeal to the imagination like an Antarctic expedition, although it may lead to far more solid results, and it generally has to sue *in forma pauperis* to Government for its support." To account for this regrettable, but undoubtedly true, fact two reasons may be adduced. There is, in the first place, the possible ignorance as to the ultimate value of the work; but, secondly, and perhaps not least, there is the fear, not entirely unjustified, that to satisfy the demands of the scientific man is something akin to the operation of filling a sieve with water. It has been so often seen that compliance with one demand only leads to another being made, that we may well sympathise with the holder of the public purse when he draws the strings tight and

refuses to pay for an arc along the thirtieth meridian in the fear that directly this is completed he will be asked to pay for one along the twentieth meridian, and then along the tenth, and so *ad infinitum*. It behoves us, therefore, as practical men to make sure that our demands are reasonable and limited to the actual requirements of the case, and where such limits cannot be set we should make this fact clear at the outset. When, however, it is possible to set such limits, we should not hesitate to do so; and in the case of the African arc this latter course is fortunately possible.

If we take the map of Africa we shall see that the arc along the thirtieth meridian passes through, or near, all the colonies of British South Africa, close to British Central Africa, or Nyasaland, through Uganda, and is thus connected with British East Africa, through the British Soudan and through Egypt. There remain absolutely untouched by it only the West Africa colonies—Nigeria, the Gold Coast, Sierra Leone, and the Gambia. These latter will eventually get their geodetic framework by an extension southwards of the French triangulation of Algeria, a work of a high order of precision. We are therefore entitled to say—and I take this opportunity of saying it with all due emphasis—that with the exception of some triangulation to join the West African colonies with the French triangulation, the arc along the thirtieth meridian is the only primary triangulation required for the adequate mapping of the whole of British Africa. The remainder of the geodetic framework can be supplied by ribs of secondary triangulation branching out from the main backbone, such as the line already completed along the boundary between British and German East Africa, passing to the north of the Victoria Nyanza and thence westward to the thirtieth meridian.

You will observe that I here speak only of the triangulation required for mapping purposes, not of that demanded by the geodesist for the study of the figure of the earth. The latter is satisfied only with a survey of the highest attainable precision covering as large an area of the earth's surface as possible, or at all events with arcs, both meridional and longitudinal at frequent intervals. It cannot be other than a very long period before the whole of Africa is surveyed upon this scale of accuracy, and in the meantime we must devote ourselves to the far more urgent duty of mapping the country, leaving the more remote and abstract task to our descendants, well satisfied if in our hands the foundations have been well and truly laid.

Furthermore, as we shall see presently, if we are prepared to recognise as a national duty the minutely precise survey of our own land and of all territories under our flag—and I do not see how any reasonable man can withhold this recognition—then there are duties of this nature lying closer to our hands than any to be found in Africa.

Having thus passed in brief review the ultimate geodetic basis of our African surveys, let us enter more into detail and glance at the actual survey work now in progress in the different regions of the continent.

In British South Africa, as we have already noted, the political conditions are at present unfavourable to any comprehensive scheme of operations. There is, however, in progress a first-class topographical survey of the Orange River Colony and a reconnaissance survey of Cape Colony. The former is an excellent example of the class of work that can be done by a small military party of the highest technical training working upon systematic lines, and I should like to devote a few minutes to a short description of the methods adopted and of the results obtained.

The survey party consists of two Royal Engineer officers and four non-commissioned officers, the former undertaking the triangulation and the general supervision of the field work, and the latter the plane tabling. The positions are primarily based upon the points of the geodetic survey broken up into a secondary triangulation with sides averaging ten miles. In 1907 the average triangular error of the secondary work was 2.9 seconds of arc, and the greatest linear errors of displacement, as tested by the geodetic triangulation at the end of a chain forty-five miles long, were three feet in latitude and two feet in longitude. The probable error of a trigonometrical height was under a foot. You will see, therefore, that the accuracy is ample for all mapping purposes, even upon

large scales, and the degree of precision is in excess of that demanded for a topographical map on the scale of two miles to an inch. The rate of progress and the low cost of work are, however, no less notable than its accuracy. The actual rate of out-turn is about eight square miles per day per man, or for the whole party twenty-three square miles of detail survey per diem, and the number of trigonometrical points fixed about three hundred per annum. The cost works out to about eight shillings per square mile of the completed map, and the whole area of 47,000 square miles will be finished, printed and published, in five and a half years.

These remarkable results are due in a large measure to the energy and organising power of the officer in charge, Captain L. C. Jackson, R.E. The detail survey is done in sheets fifteen minutes square, each non-commissioned officer being given one complete sheet, which he works at until finished. Four such sheets are therefore in progress at any given time, and each sheet takes about six weeks. Seeing the rapid rate of progress maintained, it might perhaps be thought that the country is a particularly easy one for the topographer. Such is, however, by no means the case. It is true that there is an entire absence of the surveyor's greatest impediment, large areas of dense forest, but there is much broken and difficult country, rising in places to altitudes of above 7000 feet.

In Cape Colony the reconnaissance survey is of a somewhat similar character, but owing to the large area of the country and to the small amount of money available the work has perforce to be of a more rapid nature. In Natal, Bechuanaland, and Rhodesia no survey is at present in progress.

Passing northward through Africa, we come to the British Protectorate of Nyasaland, formerly called British Central Africa. Of this country a certain number of maps exist purporting to give topographical detail; but as they are not based upon any framework of triangulation, and as much of the detail only depends upon rough sketches, it is impossible to say how far they can be accepted as correct representations of the ground.

It is most unfortunate that financial considerations prevent the execution of any systematic trigonometrical survey. The absence of such, and the fact that maps are being made which must inevitably be withdrawn and replaced by others in the future, will undoubtedly be the cause of ultimate waste of money.

Passing northward again we come to the large and important protectorates of British East Africa and Uganda, in both of which systematic surveys are in hand. The geodetic framework is supplied by a triangulation along the Anglo-German boundary, connected with chains of triangles along the railway in the neighbourhood of Nairobi. In Uganda proper there is also a triangulation covering a substantial area. As already noted, all this work will eventually be tied into the thirtieth meridional arc, though it is not likely that the final adjustment of geodetic positions thus arrived at will necessitate any substantial alterations upon the maps.

In both protectorates topographical surveys are in hand, and maps on the scale of two miles to an inch will be issued. In British East Africa, under the able direction of Major G. E. Smith, R.E., rapid progress is being made. This topographical mapping is additional to the cadastral maps also in progress in both countries. These latter are required for property purposes, in Uganda for demarcating the estates given over to the native inhabitants of the country under the agreement of 1900, and in East Africa for attachment to title-deeds of lands alienated for farming or stock-raising.

In the Soudan the enormous area of the country—more than a million square miles—and the limited funds available have prevented any systematic survey being taken up. A large amount of reconnaissance mapping has been done, and a series of sheets on the scale of 1/250,000 (four miles to an inch) have been published. These are corrected and improved by officers and Government officials as opportunity offers. The energies of the Survey Department are almost entirely spent in meeting urgent local requirements in the shape of cadastral maps of the cultivated areas along the river.

Somaliland, a British protectorate which came into un-

fortunate prominence a few years ago, is a country of too small value to be worth the cost of any sort of survey, and the only maps that exist are based upon the route sketches of travellers and sportsmen and upon the work done by a small section of the Survey Department of India during the military operations five years ago.

Leaving the east side of Africa and turning our eyes westward, we may note that in the colony of the Gold Coast a rigorous survey was rendered imperative by the gold-mining boom of 1901. The work was entrusted to Lieut.-Colonel Watherston, C.M.G., R.E. Owing to the dense forest covering practically the whole country triangulation would have been prohibitive in price and very slow in execution. The initial positions were therefore fixed by a network of long traverses, executed with all possible refinements with steel tapes and theodolites. Astronomical latitudes were observed by Talcott's method at every fifty miles. The errors of misclosure of the traverses proved to vary from about 1 in 2000 in unfavourable cases to nearly 1 in 6000—results inferior to triangulation, but at the same time sufficiently accurate to form the basis of a map with no appreciable errors *on the paper*. One great defect of the traverse method of fixing points lies in the practical impossibility of carrying the heights through without occasional checking, either by lines of levels or by trigonometrical observations. Such work makes, therefore, an imperfect basis for topography, and would only be used when natural features compel its adoption.

Northern Nigeria is a country of enormous area, and, up to the present, of small revenue. It has therefore not been found possible to allocate the funds for any systematic mapping. The existing maps are compilations based upon sketches made by civil and military officers when travelling upon duty and upon the surveys made by the different Anglo-French and Anglo-German boundary commissions. In 1905-6 Captain R. Ommaney, R.E., fixed the astronomical longitudes of fifteen towns by exchange of telegraphic signals with Lagos. With the aid of these values, combined with a number of astronomical latitudes, it has been possible to combine the material into something like a complete map. It need, however, hardly be pointed out that astronomical fixations are liable to large and uncertain errors, due to the variation of local attraction, and cannot attain the precision of even a rapid triangulation. In Southern Nigeria the experience has been somewhat unfortunate. This colony has spent a very substantial sum upon its survey department, and if the work had been properly organised and systematically carried out we should by now be in possession of a complete map of a large portion of the country. Unluckily, the mistake has been made of detaching survey parties for non-geographical purposes, such as the erection of telegraph lines, work doubtless urgently required in the interests of the colony, but not lying within the sphere of a survey department. Thus systematic progress was rendered impossible, and, though isolated pieces of triangulation and long lengths of traverses have been done, no topographical map of any area yet exists.

Of the remaining West African colonies the Gambia river is a narrow piece of land with boundaries running parallel to the river banks, and, except for the actual trade along the river, is unimportant. In Sierra Leone the country in the immediate vicinity of Freetown was surveyed by the colonial survey section, a small party employed by the War office for the purpose of making surveys of places of special military importance. The map of the remainder of the colony is a compilation based on miscellaneous material.

In the course of this summary of the state of the mapping of British Africa mention has been made of the surveys made by joint commissions appointed for the delimitation of international frontiers. No small part of the existing map is due to work of this class. Thus joint Anglo-French commissions have marked out the frontiers of the Gambia, Sierra Leone, the Gold Coast, and Nigeria; Anglo-German commissions the eastern boundary of Nigeria, the boundaries between British and German East Africa, between German East Africa and North-East Rhodesia from Lake Nyasa to Tanganyika, and between Bechuanaland and German South-West Africa; Anglo-

Portuguese commissions the frontiers between Portuguese East Africa and North-East Rhodesia and Nyasaland respectively. Useful surveys have also been made in the course of the mutual demarcation of the frontiers between Abyssinia and the Soudan on the west and British East Africa on the south; also of the frontier between the colony of Sierra Leone and the Republic of Liberia.

Important as the work done by these commissions has been, its value would be greatly enhanced if the reports of each commission were published in a succinct and easily accessible form. Such reports would naturally contain a record of the actual frontier as finally ratified, and also a technical account of the survey methods employed. They would thus be of permanent use both to the official or officer on the spot for the easy settlement of any disputes that may arise, and to the chief of any future boundary commission as an aid to the selection of the methods of survey most suitable to the particular country with which he is concerned.

Up to three years ago many of the African protectorates were under the tutelage of the Foreign Office, while the older colonies were under the Colonial Office. The reports of Boundary Commissions are therefore scattered through official documents in the two offices, and are drawn up upon no uniform model. Now that the superintendence of all these territories has been handed over to the Colonial Office, and that body has set itself such an excellent example in the appointment of the Colonial Survey Committee and the publication of its reports, it is greatly to be hoped that they will follow up the good work and systematise and publish all these Boundary Commission reports. If a model for such a publication is desired, I may refer to the account of the demarcation of the Turko-Egyptian frontier between Rabah on the Mediterranean to the Gulf of Akaba, lately issued by the Egyptian survey.

The account which I have endeavoured to give you, short and imperfect as it is, of the present state of the mapping of British Africa will have shown you clearly that there is a large amount of excellent work now in course of execution, and that there has been, especially during the last few years, very considerable progress made towards coordinating this work and towards maintaining certain fixed standards of accuracy, rapidity, and economy.

It will naturally occur to you to inquire whether this coordination could not advantageously be pressed a step further, and whether all the isolated survey departments, now working in the various colonies and protectorates, could not be amalgamated under one executive head; whether, in fact, a Survey Department of Africa, precisely analogous to the Survey Department of India, could not be formed. The advantages of such a step are obvious, but must not be allowed to blind us to the difficulties. We have, in the first place, the objection to be met that the South African colonies would, in present circumstances, almost certainly refuse to join in any general scheme, and would not consent to any arrangement whereby money raised in one colony would be spent outside its own geographical limits. If, however, we leave South Africa out of the question, the financial difficulty tends to disappear. Both our East and West African possessions are, in general, not yet in a position to maintain themselves, and are still, and will be for some time to come, partially supported by grants from the Imperial Treasury. To divert a portion of these grants to pay for the maintenance of a survey department would only be a matter of account, and could be adjusted so as to cause no hardship to any one colony. There remains the geographical difficulty of space. The fact that the heads of the department would have to keep in close personal touch with countries differing entirely in character, and perhaps three months' journey from each other, does not appear to offer any insuperable objections, and I cannot avoid expressing the hope that it may be found possible at a no very remote date to take some steps in the direction of a consummation which appears so desirable.

In giving my evidence before the Royal Commission on the War in South Africa, presided over by Lord Elgin, I outlined the general features of a scheme under which the Imperial Government would undertake the topographical mapping of all our oversea possessions, apart from self-

governing colonies. As on this occasion I was considering the whole question more exclusively from the military side, no reference was then made to the question of cadastral maps, and it was tacitly assumed that these would fall to be constructed by the land office or a land survey department belonging to each separate colony. On the present occasion we are not restricted to the military point of view, but are permitted a wider outlook. Our task is to consider the map in all its aspects, both as regards its method of construction and its ultimate use, whether for military, administrative, engineering, or purely scientific purposes. This enlargement of our scope does not, I think, modify our previous conclusions, and were I now called upon to devise a scheme for the mapping of British Africa, I should base it upon the principle of a central Imperial body for executing the triangulation and topography, leaving the land survey to local organisations.

The arguments in favour of this policy are manifold. As regards the triangulation they hardly require stating. It will be obvious to all that such work must be closely coordinated, and that some central, directing head is imperatively called for. The enormous waste of money that is ultimately involved by tolerating imperfect work, of which many examples could be cited, is alone a sufficient justification for holding this view. We may, however, pause to examine a little more closely into the advantages of centralisation as regards one particular operation in a survey. That is the measurement of the initial base line upon which the accuracy of the whole framework depends. This task used to be one of the most laborious and difficult with which the surveyor is confronted. The apparatus employed, some form of compensation bar, was cumbersome and difficult to use, the site selected had to be levelled, and the preparatory alignment carried out with the most scrupulous care. Thus the Loch Foyle base for the triangulation of Great Britain and Ireland was about six miles long, and the actual measurement, quite apart from the time spent on the preparation of the ground, took sixty days, an average rate of work of just more than 500 feet per working day.

A few years ago the discovery was made of the nickel steel alloy with a very small or zero coefficient of expansion, the so-called invar. This valuable metal, by abolishing the necessity for any temperature correction, has enormously simplified all physical measurements of length, and, *à fortiori*, those measurements, such as base lines, which are performed done in the open air and over a large range of temperature. Survey bases are now measured with an invar wire stretched to carefully regulated tension, and either laid along a flat trough, or what appears to give equally good results, hung freely between supports. The gain in precision due to the avoidance of errors of expansion or contraction in the measuring apparatus is substantial, while the gain in rapidity is very great. Thus, as a contrast to the Loch Foyle base, let me give a short account of the measurement of a base in Spitsbergen by the Russian party of the joint Swedish and Russian missions in 1900, extracted from a review already written for the *Geographical Journal*.

The conditions for accurate work were very unfavourable: no site even approximately flat could be found, and the base was therefore irregular in contour and traversed rough and in some parts marshy ground. The weather conditions were far from ideal. The cycle of operations was as follows: An auxiliary base 175 metres long was measured with Struve's apparatus, twice before the main base measurement and twice afterwards. The two wires used for the main base were standardised on this subsidiary base four times, twice before and twice after use. The main base, 6.2 kilometres long, was measured twice in each direction by each of two wires, eight measures in all. The limit of error in the final value was 17 millimetres—say, one part in 360,000.

The whole of these operations, including the laying out of the standard and the comparison of the wires, were completed in a period of three weeks; Monsieur Backlund, who superintended the actual measurement, left the observatory at Pulkowa on June 11 and returned to it on July 24. It was therefore possible to standardise the wires not only by the check base upon the spot, but also by the permanent standards of the observatory within

three weeks of their use for the actual measurement. It need hardly be pointed out that this was eminently favourable to the attainment of the highest exactitude, and we have here a marked example of the value of centralisation. The proposed trigonometrical survey department of Africa would probably find it advantageous to adopt similar procedure, and, instead of trusting a base measurement to a local staff unacquainted with the work, it would send out one or two men of highly trained technical skill equipped with the best apparatus. The money spent in journeys would be more than saved—firstly, by the unquestionable gain in accuracy and the consequent avoidance of the costly necessity for repeating bad work; and, secondly, by the gain in time, due to the fact that the local staff would not be called upon to learn the use of an unfamiliar set of instruments.

Similar advantages would arise from a partial specialisation of the angular measurements. Thus the first-class observer with a theodolite must possess certain qualities of eyesight, health, and judgment, rarely combined in one individual. When such a combination of qualities is found it should be made the best use of, and a good man should not be wasted on second-class work. At present, upon the system of regarding each colony as an isolated unit, it is not possible to employ every man to the highest advantage, and there are doubtless many examples at present in Africa of able men being set tasks much below the standard of their ability, and, *per contra*, men of no such qualifications being given work beyond their powers. It is only by working with an extended organisation, employing a large staff and responsible for a large area of country, that any approximation can be made towards that ideal wherein every member of the establishment is used to the best advantage according to his special qualifications.

To turn from the triangulation to the question of topography, we shall find analogous arguments in favour of entrusting this work to one central department. Whether we consider the necessity for a uniform system of training for the topographer, or whether, looking at the matter from the other side, we consider the desirability of a close degree of uniformity in the resulting map, we arrive at the same end. Nor need we confine ourselves to theoretical arguments; practical results are before us as examples. It is not possible at the present moment to point out a single case of a thoroughly satisfactory topographical map of any country whatever which has not been executed by men trained in a properly organised survey department or, what is equivalent, in the Corps of Royal Engineers. Examples of failure to accomplish this are numerous. Thus we have the cases of the British Colonies in South Africa before the war; of Canada, where no topographical map existed until two years ago, when the work was taken up by the military department; and of Ceylon, where, in spite of the vast sums spent on survey and the small size of the island, no topographical map of the slightest pretensions to completeness exists of any part of the country.

It may also be noted that, especially in the case of a developing country, it is of enormous advantage that the map shall be begun and finished within some reasonable time. If a long interval elapses between the commencement and the completion, the first sheets are out of date before the last are done, and the whole exhibits a most undesirable lack of uniformity.

With a central organisation the mapping of each protectorate can be taken up in turn and dealt with rapidly, thus producing a homogeneous map impossible to a small local body. Upon the converse point, the question as to whether our central department should or should not undertake cadastral survey, the arguments are perhaps not so one-sided. It is, however, quite clear towards which side the balance of advantage tends. Taking into account the intimate connection of the cadastral survey with the system of land holding and land taxation, the fact that these systems necessarily vary and that as a financial matter of account the receipts and expenditure of each colony are separate, it is not difficult to see that the land survey is better left to local control. This would not preclude any particular colony from arranging with the central body for the execution of any definite piece of

work of this class, upon terms agreeable to both sides, in a similar manner to that in which cadastral survey is executed by the Indian survey for provincial Governments, and it need hardly be pointed out that the geodetic points fixed by triangulation would in any case be available as a framework for the large-scale map.

The geographical survey of the British Empire, apart from Africa, will not on this occasion detain us long. I exclude from present consideration the great self-governing colonies—Canada, Australia, and New Zealand—and also the whole country lying within the sphere of the survey of India. Ceylon has an elaborate land survey system; and though, owing to past mistakes, the geographical mapping of the island is in a most lamentably backward condition, there are good grounds for hope that this state of affairs will be remedied in the near future. The Malay States, where, owing to the fertility of the soil and the ubiquity of rich tin ore, the land values are high, have the basis of an excellent survey system, and possess a backbone of triangulation which will eventually extend southward to Singapore, and possibly northward to join the Indian series in the south of Burma. Hong Kong, including the leased territory on the mainland, is of small area and of no appreciable geographical importance. It has been adequately mapped for military purposes. Of our insular possessions, Mauritius, St. Helena, and (in the Mediterranean) Cyprus and Malta are thoroughly surveyed. The other islands scattered throughout the ocean which fly the Union Jack, including the West Indies, while their coast lines have naturally been the subject of close attention by the Hydrographic Department of the Admiralty, are, as regards their internal geographical features, still quite imperfectly known. The large and important territory of British Guiana is entirely unsurveyed, and indeed in part almost unexplored.

You will thus realise that if we are prepared to admit the validity of the premiss that the mapping of its own territory is an imperative duty of a State which aspires to justify itself before the nations as the possessor of a world-wide Empire, there is still plenty of employment for the scientific geographer in the British dominions.

Having thus far spoken of our duties and obligations, for such they appear to me, which lie abroad in countries remote from our own shores, let us now turn our eyes inward and see if we cannot discern some similar duties lying close to our hands.

I take it that the great majority of us have been brought up in the idea that our own Ordnance Survey is of such a high order of accuracy that a proposal to undertake a revision of the fundamental triangulation of the British Isles must appear strange. Yet this idea will not be a new one to the British Association, for two years ago at the York meeting I brought the subject before this Section in a short note, which gave rise to a useful discussion.

What I shall say now will be in a large measure a repetition of my previous remarks, a repetition for which I need offer no apology, as it will be apparent to you that had any steps been taken to remove this standing reproach to British geodetical science no recurrence to the subject would be called for. As matters stand, however, I feel impelled to recur to it with increased emphasis, a position in which I am confident of being supported by all those who earnestly care for the scientific repute of our country. Some few years ago, at the request of the International Geodetic Conference, a volume was prepared by General Ferrero, the eminent Italian geodesist, giving a summarised account of all the geodetic surveys of the world. If we take this volume and examine the relative degree of precision of the different national surveys there enumerated we shall find that Great Britain stands lowest on the list.

The popular illusion, for it is really no other, as to the extreme accuracy of the triangulation of the British Isles rests in no small degree upon what must be considered a fortuitous circumstance—namely, the accidental smallness of the closing error. Have we not all been told how at the conclusion of the triangulation, when the observations had been carried from the primary base on the shore of Loch Foyle across part of Ireland and across Wales and England, terminating in two points on Salisbury Plain, the distance between these points was calculated, using as data the measured length of the Loch Foyle base and

the observed angles of the triangles across the country? The distance between the same two points was then measured with every refinement of accuracy, and the measured length compared with the calculated length. The difference between them was found to be twenty inches. If in traversing a large portion of the kingdom the aggregate error only amounted to this minute quantity—minute, that is, compared with the distances involved, how can we either expect or demand a better result, even if the work be re-done with the most refined methods that the accumulated experience of the last fifty years can suggest?

To answer this question we must bear in mind that the closing error of a piece of work such as a triangulation is not the only, nor indeed the best, test of its precision. A small closing error may be due to accident; larger discrepancies may have occurred at intermediate stages which have chanced nearly to cancel themselves at the end. Such undoubtedly did happen in this case. The work was not as accurate as the smallness of the closing error would seem at first sight to imply. We have, however, in such a case an absolute measure of relative precision in the magnitude of the average triangular error, being the quantity by which the sum of the observed angles of a triangle exceeds or falls short of the true value of $180^\circ +$ spherical excess.

From this we can readily deduce the "probable error" of a single observed angle, a form in which the measure of precision of a triangulation is often expressed.

In our British survey this quantity equals 1.20 second of arc, while in good modern work it does not in general exceed 0.25 second. Making due allowance for the fact that the network of triangles over our islands is a complicated one, and therefore that the ultimate precision is considerably greater than that of a chain of triangles of the same order of individual accuracy, we are probably justified in concluding that a re-survey would at least halve the final errors.

Such a re-survey is urgently demanded in the interests of international geodesy.

It will of course be clearly understood that this implies no adverse criticism upon the work of the men who originated and carried out the primary triangulation of the British Isles. For that great achievement we must all have the most sincere admiration. It was pioneer work of the highest order; it set a standard of accuracy never before attained, and was for long taken as the model for such work in other countries. It was, however, started at the end of the eighteenth century, and was completed in 1857. It is therefore hardly surprising that it falls somewhat short of the precision of modern observations of the same class. It will also be understood that this re-survey does not affect the question of the trustworthiness of our Ordnance Survey maps. Any errors which exist in our triangulations are important only for geodetic discussions, such as the determination of the exact figure of the earth, and are quite negligible for map-making purposes. There can be no appreciable error from this cause upon the maps of our own country, even those on the largest scales, and no question of reconstructing our maps can arise. This is fortunate from the financial point of view. Such a reconstruction would involve a very heavy expenditure, while the cost of the re-triangulation suggested would be quite trifling compared with the actual annual expense of our national surveys.

The result of this inferiority in accuracy of the British survey is that it is useless to coordinate it with the Continental series for geodetical purposes. This defect is all the more noticeable in that the necessary observations for joining up the two series were actually made. Three stations on the coast of Kent—St. Peter's Church, between Margate and Ramsgate; Coldham, a hill about two miles north of Folkestone; and Fairlight, a hill about four miles north-east of Hastings—were connected trigonometrically with three stations in France—Montlambert, near Boulogne; St. Inglevert, over the village of Wissant; and the Clock Tower at Gravelines. This was done in 1861-3. The observations were of a high order of precision. It would not be necessary to repeat them.

The importance of the coordination is apparent when we inspect a map of Europe with the neighbouring part

of Africa, upon which the triangulation lines are entered. We then see that the British part of the work is imperatively required to extend, and in fact to complete at one end in each case, two important geodetic arcs, viz., the meridional arc along the meridian of Greenwich and the longitudinal arc along the latitude of 52° north. Without the British portions these arcs extend from Ain Sefra in Algeria to Gravelines in France, an amplitude of 18° , and from Orsk in Russia to the same point in France, an amplitude of 57° . With the British section added they would be further extended to Saxavord, the northernmost point of the Shetland Islands, and to Valentia, on the West of Ireland, respectively. The added amplitudes would be 10° and $11\frac{1}{2}^{\circ}$, very material additions, which would undoubtedly prove of substantial scientific value.

It will thus be seen that it is by no means necessary, or even desirable, to re-observe the whole network of triangles covering our islands. All that is required is to connect geodetically the three extreme points—Saxavord, Valentia, and the stations on the Kent coast just mentioned.

A knowledge of the exact figure of the earth is of high scientific importance, especially so in reference to recent speculations as to its possible deviation from a spheroidal form. It cannot be other than a subject of national shame that so important a link in this research remains unfilled. We may note with gratification the forward position that our nation has in the past taken in the advancement of geodesy. We know the great work done in the triangulation of India, and we have alluded to the magnificent conception of the Cape to North Sea arc due to Sir David Gill. Surely it is not asking too much that we should take steps to set our own house in order, and to ensure that our own triangulation is at least as accurate as that covering the neighbouring portions of the continent of Europe. The subject is one upon which the powerful influence of the British Association might legitimately be brought to bear, and any representations from our body would come with a peculiar appropriateness from this the Dublin meeting, seeing that so large a section of the work, the importance of which we wish to urge upon the Government, lies upon Irish soil, the execution of which would therefore devolve naturally on the Ordnance Survey of Ireland.

In concluding this address I feel constrained to apologise for what may have appeared to some of you the dull and unromantic character of my theme. I am too well aware that to many the idea of geographical advance is confined to the perilous traversing of virgin lands, to the navigation of unknown waters, and to the penetration of forests or deserts never yet trod by white men's feet. I am conscious that the substitution of the surveyor for the explorer has necessarily destroyed much of the old romance, and that the feelings born when any fraction of the earth's surface was for the first time opened to our ken can never be revived. While, however, the romance has gone, the dangers remain, and there is as much call now for unflinching courage and for unselfish devotion to duty as there was in the days when the search for the sources of the Nile was an impelling cause sending adventurous men into the unknown. Whether occupied in cutting his way through the almost impenetrable forests of the Gold Coast or struggling with the papyrus swamps of the Nile basin, or whether, standing upon the top of some old volcanic hill, he is engaged in scanning the blue distances of the great Rift valley, the surveyor is not less worthy of your admiration than the earlier traveller whose name is perhaps honourably enshrined in that of river or mountain. Whether pushing his way through the jungles of the Malays or floating upon the muddy stream of an African river, whether he is braving the attacks of savage animals, of treacherous natives, or the far more insidious assaults of the germs of some deadly disease, he is equally deserving of your sympathy and your encouragement. He is in truth a shining example of the power of that spirit of adventure and thirst for information which has carried our race so far in the past, and which in the future is, we all trust, destined to lead us ever "upwards and on"; the spirit that esteems no sacrifice too great in the cause of duty, and recognises no duty so high as that of making some contribution towards the increase of natural knowledge.

NO. 2029, VOL. 78]

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

LONDON.—A course of nine post-graduate lectures on "The Scientific Principles of Radio-telegraphy and Radio-telephony" will be given by Prof. J. A. Fleming, F.R.S., at University College on Wednesdays, beginning October 14. The introductory lecture will be addressed to a general audience, and no charge for admission is to be made. Cards of admission must, however, be obtained beforehand by those attending. The succeeding lectures will be free to graduates of the University and to undergraduates in their third year who may be qualified to take advantage of them. A fee of two guineas for the course will be charged to all other persons. Those desirous of attending the course should apply to the secretary, University College, Gower Street, W.C.

THE Rev. W. Lower Carter has been appointed lecturer in geology at the East London College.

PROF. JOSEF MOELLER, of Graz, has been appointed to the chair of pharmacognosia at the University of Vienna.

THE foundation-stone of a new college for the training of teachers was laid at Dudley on Thursday last by the Countess of Dudley. The cost of the building (which will accommodate 100) is 19,000*l*.

CLASSES for the instruction of miners are being started at Hamstead by the Staffordshire County Council, which will, it is hoped, enable many miners who possess sufficient practical knowledge, but who lack the necessary scientific and other training, to fill higher positions in the mines.

THE new municipal college at Portsmouth was opened on Thursday last by the Mayor of the town. The building, which is the outcome of a scheme for higher education organised by the local education authority, is an adaptation of the best ideas of the principal technical institutes of the country to the requirements of Portsmouth, and is stated to be in its equipment one of the most modern in England.

THE following arrangements have been made for the opening of the winter session of certain of the medical schools. At Guy's Hospital (in connection with the Physical Society), Sir R. Douglas Powell will deliver an address on October 8 entitled "Just Procedure of Medicine"; Dr. Charles Slater is to speak on October 1 at St. George's Hospital on "The Laboratory in Medical Education and Practice"; on the same date an address will be delivered at the Middlesex Hospital by Dr. A. M. Kellas; at King's College Hospital Prof. Alexander MacAlister, F.R.S., will deliver an address on October 1; Sir Edward Fry, F.R.S., is to speak at University College Hospital on October 2. At St. Mary's Hospital, on October 1, an address is to be given by Sir John Broadbent; Dr. Harrington Sainsbury is to speak on the same day at the London School of Medicine for Women; at the West London Post-graduate College an address is to be given on October 13 by Sir R. Douglas Powell; Dr. R. Jones is to speak on "Insanity, Wit, and Humour" on October 1 at the Polyclinic; at the North-East London Post-graduate College Mr. Jonathan Hutchinson, F.R.S., is to speak on October 8; Sir T. Clifford Allbutt, K.C.B., F.R.S., is to give an address at the University of Manchester, on October 1, on "Hospitals, Medical Science, and Public Health"; and at University College, Bristol, on October 1, Sir Rubert Boyce, F.R.S., is to speak.

THE approaching winter session in our technical colleges and schools is being heralded by the publication of numerous attractive and carefully compiled year-books and prospectuses of the various institutions in London and the provinces. We have received a number of these helpful guides, and, without exception, they provide intending students with valuable assistance in the choice of classes and hints from experienced teachers as to how to plan courses of work likely to be of service in various industries. Among recent syllabuses published in connection with London institutions we notice those of the Northampton Polytechnic Institute, the Sir John Cass Technical Institute, and the East Ham Technical College. At the Northampton Institute there are provided